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DESIGN OF AN INTRINSICALLY SAFE INSTRUMENT PACKAGE FOR A PORTABLE GAS CHROMATOGRAPH

FINAL REPORT
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EXECUTIVE SUMMARY

The Cape Breton Coal Research Laboratory has developed a rapid sequential trace gas analyzer for studies of air flow patterns in coal mines. The analyzer consists of a gas chromatograph (GC), detector, controller and data logger. Regulations governing coal mines require electrical equipment to be certified for operation in mines. The Canadian Explosive Atmosphere Laboratory (CEAL), a division of Energy, Mines and Resources Canada, provides a certification service recognized and approved by the mining authorities.

Atlantic Nuclear Services undertook to qualify the trace gas analysis system for service in a gaseous coal mine environment. The project scope specified using existing commercial components that have an intrinsic safety certification or could be modified easily for certification.

The commercial market was surveyed to determine if the components of the instrument package were available already certified for intrinsic safety. An intensive mail, telephone and computer survey of vendors in Canada, the United States and Great Britain uncovered only two intrinsically certified components; a data logger and a strip chart recorder.

In view of the non-availability of certified devices, non-qualified components that were the best candidates for certification were identified. These included an electron-capture detector (ECD) and valve controller by VALCO and a complete and portable GC/ECD unit - the Scentograph - available from SENTEX. The feasibility of re-designing these products to meet intrinsic safety standards was examined.

The CEAL certification for intrinsic safety is based on the CSA Standards. To show conformance to these standards requires detailed product information from the manufacturers, much of which is of a proprietary nature. Without the specific details on the manufacture of the components, qualification of the instrument package through evaluation and re-design of available components was not possible.

The CEAL recognizes two alternative design approaches for providing protection: explosion-proof enclosures and pressurized/purged systems. Both methods were examined. The relative advantages and disadvantages of each of these methods of protection are summarized below.

Explosion-proof enclosures are cast-iron or covered aluminum boxes designed to withstand the force of internal explosions and cool escaping gases to prevent external explosions. The main advantage is that there is no need to re-design the instrument components. The main disadvantage is that the mass of the enclosure grows very quickly with the volume to be enclosed, reducing portability.

Pressurized/purged enclosures involve continual purging of a contained system at a positive pressure to isolate the system from the potentially explosive external atmosphere. The main advantage of this method is that the enclosure does not need to be as massive (as explosion-proof enclosures), thereby increasing portability. The main disadvantage is that protection involves extensive safety features which complicate and encumber a system.

Examination of the three approved methods of protection in conjunction with the best available components and all relevant certification requirements has resulted in a final recommended design. Protection of the instrument package would be best achieved with

covered aluminum explosion-proof enclosures. Furthermore, the VALCO ECD and valve controller are the most suitable components for protection by the enclosures.

RÉSUMÉ ADMINISTRATIF

Le Cape Breton Research Laboratory a mis au point un analyseur de gaz de traces par séquence pour l'étude des configurations de la circulation d'air dans les mines de charbon. L'analyseur se compose d'une chromatographe en phase gazeuse (CPG), d'un détecteur, d'un contrôleur et d'un enregistreur de données. Les règlements qui régissent les mines de charbon exigent que le matériel électrique utilisé dans les mines soit certifié. Le Laboratoire canadien de recherche sur les atmosphères explosives (LCRAE), une division du ministère de l'Énergie, des Mines et des Ressources du Canada, offre un service de certification reconnu et approuvé par les autorités minières.

Atlantic Nuclear Services a entrepris de faire certifier le système d'analyse de gaz de traces pour l'utilisation dans une mine de charbon d'où émanent des gaz. Le projet prévoyait l'utilisation de composantes commerciales existantes qui sont certifiées au point de vue de la sécurité ou qui pourraient être facilement modifiées pour fins de certification.

Le marché commercial a été analysé afin de déterminer si les composantes du matériel disponibles étaient déjà certifiées au point de vue de la sécurité. Un sondage exhaustif par courrier, par téléphone et par ordinateur effectué auprès des vendeurs au Canada, aux États-Unis et en Grande-Bretagne a révélé qu'il n'y existe que deux composantes certifiées; un enregistreur de données et une enregistreuse sur bande.

Étant donné l'absence de dispositifs certifiés, on a identifié les composantes non certifiées qui étaient les plus aptes à la certification. On a noté entre autres un détecteur d'electrons (DE) et un contrôleur de valve par VALCO, une unité - CPG/DE complète et

portative - le Scentograph - pouvant être obtenue de SENTEX. On a étudié la faisabilité de modifier la conception de ces produits afin de répondre aux normes de sécurité.

La certification du LCRAE pour la sécurité est fondée sur les normes de l'ACNOR. Le respect de ces normes nécessite de la part des fabricants, de l'information détaillée sur le produit dont la majeure partie est de l'information générale. Sans les détails précis sur la fabrication des composantes, il était impossible d'établir l'aptitude à la certification du matériel par l'évaluation et par la modification de la conception des composantes.

Le LCRAE reconnaît deux approches en matière de conception afin d'assurer la protection: systèmes d'enceintes antidéflagrantes, et d'enceintes pressurisées et épurées. On a étudié les deux méthodes. Les avantages et les inconvénients relatifs de ces méthodes de protection sont résumés ci-dessous.

Les enceintes antidéflagrantes sont des boîtes en fonte ou des boîtes en aluminium couvertes conçues pour résister à la force des explsions internes et pour refroidir les gaz d'échappement afin de prévenir les explosion externes. L'avantage principal de ce système, c'est qu'il n'est pas nécessaire de modifier la conception des composantes de l'instrument. L'inonvénient principal, c'est que la masse de l'enceinte augmente très rapidement avec le volume à blinder, ce qui en réduit la nature portative.

Les enceintes pressurisées et épurées comportent l'épuration continue d'un système fermé à une surpression afin de l'isoler de l'atmosphère externe potentiellement explosive. L'avantage principal de ce système, c'est que l'enceinte n'a pas besoin d'être aussi massive (que les enceintes antidéflagrantes), ce qui en augmente la nature portative. L'inconvénient principal, c'est que la protection comporte

des caractéristiques de sécurité qui compliquent et encombrent un système.

On a recommandé un conception finale après l'étude des trois méthodes de protection approuvées, des meilleures composantes disponibles et de toutes les exigences pertinentes de certification. Le matériel offrirait une meilleure protection s'il était muni d'enceintes en aluminium couvertes et antidéflagrantes. De plus, le DE de VALCO et le contrôleur de valve sont les composantes les plus aptes à être protégées par les enceintes.

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1.0 INTRODUCTION

The technique of tracer gas measurement is an important tool in mine ventilation studies. In gaseous coal mines, where consistent ventilation is a serious problem, this technique is particularly useful in mine evaluation.

To date, however, tracer gas measurements have been limited to a grab sample technique with later laboratory analysis. This is a time-consuming process requiring one or more days for all the samples to be processed and analyzed. Problems requiring prompt identification in order for action to be effective are beyond the capability of present technique.

A portable instrument capable of real-time sampling and analysis would enable on the spot determination of air flow patterns and circulation rates. This would permit corrective action to be initiated as soon as a problem is spotted or while it develops. This in turn would accelerate response time, ultimately improving ventilation and raising the standard of safety within the mine.

The Cape Breton Coal Research Laboratory (CBCRL) has developed a rapid sequential tracer gas analyzer for determining trace levels of SF_6 in air. The design is a synthesis of several commercial stand-alone units as well as a plumbing and valving arrangement developed by the Scientific Authority. Although the analyzer had been tested successfully in the uranium mines at Elliot Lake, Ontario, stricter regulations governing coal mines prohibit testing in a coal mine until proper safety certification has been obtained.

Atlantic Nuclear Services was given a mandate to develop an instrument package that would be both intrinsically safe and CEAL approved. The specific design requirements are given in the Statement

of Work included in Appendix A. The instrument package would include an electron-capture detector (ECD), valve controller and data acquisition system.

Development of the instrument package was to proceed in two steps. First, the commercial market would be searched for intrinsically safe components available and suitable "as is". In the event that the necessary qualified components were not available, the second step would be taken to identify those components that could be easily modified through re-design.

Obtaining qualification for the gas chromatograph (GC) was to be the responsibility of the Scientific Authority. The scope of this project was based on the assumption that the GC would require little or no modification to meet intrinsic safety requirements.

This report outlines the work undertaken by ANSL to identify suitable intrinsically safe components and all applicable safety standards of the qualification process. The survey of vendors for qualified commercial components is described in Section 3.0. Section 4.0 discusses the components that were selected for evaluation and possible re-design.

There are strict requirements for the safety design of instruments to be used in a coal mine. In Canada, the Canadian Explosive Atmospheres Laboratory (CEAL), a division of Energy, Mines and Resources Canada, provides a certification service that is recognized and approved by the mining authorities. The CEAL bases its certification process on the CSA Standards for intrinsically safe (I.S.) electrical equipment. The safety requirements for coal mines are reviewed in Section 3.

From the survey of vendors it was found that there are no commercially available electron-capture detectors, valve controllers or gas chromatographs that are certified intrinsically safe. The main reason for this unavailability is the difficulty in obtaining certification and the limited market for the product. As a result, explosion-proof enclosures and pressurized/purged systems were considered as alternative methods of protection. These alternative designs approaches are described in Section 5.0

The findings of the study are summarized in Section 6.0. An instrument package protected by an explosion-proof enclosure is recommended as the best available design approach.

2.0 SURVEY OF VENDORS

A survey of vendors was conducted as the first step in the qualification of the trace gas detection system. The object of the survey was to identify commercially available, intrinsically qualified components suitable for the instrument package. The review was carried out primarily by means of a mail survey of potential vendors.

In addition, the on-line computerized databases of the Canadian Institute for Scientific and Technical Information at the National Research Council was searched for relevant information. These databases can be accessed through the CAN/OLE System on which ANSL maintains an account.

Telephone conversations and interviews with consultants for both the coal industry and its suppliers yielded additional information on components presently in use in Canadian coal mines. These consultants offered valuable information on the opinion of the industry towards safety and protection as well.

A list of potential suppliers was drawn up from Buyer's Guides and Technical Journals. A letter was drafted outlining the object of the project and the need for information on the products of interest. Few details were given on specific design requirements so as not to limit the response. If exact components could not be found, those that could easily be modified would be investigated. A copy of this letter and the list of companies canvassed are included in Appendix B.

2.1 Summary of Responses

Fifty-eight companies across North America were solicited for product information. A response was received from sixty-four percent of those surveyed. As was expected, a higher percentage of the returns came from Canadian addresses than from U.S. addresses (77% compared to 58%). The vendors that responded are identified in Appendix B.

Only a few of the companies responded to the specifics of our request. The typical response from a supplier/manufacturer was a standard pre-packaged folder of brochures and/or catalogues. A sample of the product literature received is included in Appendix C. The products offered fall into roughly two categories: (1) complete gas chromatograph systems and (2) gas detection/monitoring units.

The information received was examined for products of potential interest. At this stage, components were not screened for intrinsic safety qualifications. Ten firms were sent second letters requesting additional information - schematics and specifications for specific products. The ten firms selected for follow-up requests are identified in Appendix B. Follow-up calls to many of the firms were required to expedite responses.

Of the ten firms that were sent second letters requesting additional information on particular products, only VALCO cooperated. Although our request stressed the recognition of the proprietary nature of much of this material and our willingness to sign any documents of disclosure, the detailed information we required was not forthcoming. The majority of firms responded to the second request or telephone call by sending the same brochures that were first received. It became clear that until the products are actually purchased, information will be limited.

A search of the NRC Library, accessed through CAN/OLE, was initiated to supplement the mail survey. An extensive search of the following databases resulted in seven citations of interest:

- Chemical Abstracts (CAC, CAS77, CAS82)
- Coal Abstracts (COAL)
- Coal Research Projects (COALPRO)
- EI Engineering Meetings (EIM)
- Engineering Index (EI)
- Geological Reference File (GEOREF)
- Information Services for the Physics and Engineering Communities (INSPEC)
- National Technical Information Service (NTIS)

Examination of the citations, however, did not reveal any concrete information that could be directly applied to the design of the detection system. Instead, the papers emphasized the need for proper evaluation and identification of hazardous locations, the concept and history of intrinsic safety, and the common sources of potential danger. No new or applicable data was extracted from these papers. Furthermore, the CAN/OLE search failed to produce any citations specifically for an intrinsically qualified tracer gas detection system.

2.2 Industry Perspective

As part of the survey for qualified instrument components, the perspective of instrument vendors and mine safety professionals was actively solicited.

Consultations with industry people in the course of the survey of vendors revealed a general consensus against the use of intrinsic

safety as a means of protection in coal mines. As well, suppliers/manufacturers of non-qualified components are generally not in favour of modifications to their products to meet safety requirements.

An example of the vendors' view is that of Barbara Fanning, a chemist and representative for Hewlett Packard. She expressed concerns about the quality of results and integrity of equipment constrained by the hazards of the coal mine environment. Ms. Fanning advised against modifications to any of Hewlett Packard's GC systems or portable computers.

A view from the mining industry was offered by Sam Schwartz, chief electrical engineer at the Devco Mine in Nova Scotia. He cautions against making electrical equipment intrinsically safe. Furthermore, he believes that the mining community as a whole favours explosion-proof enclosures over intrinsic safety as the preferred safety option.

2.3 Conclusions

The following observations and conclusions are a result of the survey of vendors undertaken in the search for suitable components:

(1) A tracer gas detection system, such as the one outlined in the project proposal, is not commercially available (I.S. qualified or otherwise).

(2) Very few I.S. qualified components exist on the market. The components specific to this project are not available as intrinsically qualified devices.

(3) Most companies supply complete GC systems suitable to a stationary laboratory bench top only. These systems are not portable or transportable.

(4) Very few stand-alone components are available. This limits the choices for such things as carrier gas supply, beta source, sampling frequency, limits of detection, etc.

(5) Manufacturers of non-qualified products and industry people alike are wary of design modifications to existing products that would permit operation in a gaseous coal environment.

3.0 SAFETY REQUIREMENTS FOR COAL MINES

The potential consequences of an explosion in a coal mine has led to the development of rigid safety standards for mine equipment. The inspection of mines and enforcement of safety rules are provincial and sometimes federal responsibilities. Jurisdiction over the Cape Breton coal mine, the intended location of the instrument package, belongs to the Federal Department of Labour (i.e. Labour Canada).

3.1 The Gaseous Mine Environment

The gaseous coal mine is considered a hazardous location and thus subject to strictly enforced rules and regulations. Standards exist to facilitate the regulation of the mine and to promote safe operation in spite of the hazards.

The Canadian Electrical Code (CEC) governs the operation of electrical equipment in mines. Rules for hazardous locations are necessarily more stringent that those for non-hazardous locations. Similarly, the type and severity of the hazardous environment can vary considerably, even within a few feet. Therefore, the CEC maintains a classification scheme for harsh environments based on the type and degree of hazard.

The CEC's classification scheme uses three classes, two sub-divisions and seven groups. Coal mines are considered a special case and given only one classification status; Class 1, Gaseous Mines. It is the additional presence of explosive coal dust that warrants this special rating. For purposes of comparison, however, coal mines are roughly equivalent to a Class 1, Division 1, Group D classification.

Methane is the flammable gas that can exist in coal mines during normal operation. Because of the high levels encountered and inconsistent ventilation, the hazard from methane is increased significantly. Coal dust is also explosive and its presence compounds the hazard further.

Electrical energy of sufficient potential can ignite a methane/air/dust atmosphere. Although both methane and coal dust have minimum ignition points (below which ignition cannot occur), these are sufficiently low to cause problems in the ordinary operation of electrical equipment. The danger results from the production of hot sparks or arcing caused by short circuits, overloading or breaks in conductors.

To be more specific, gas particles of sufficient excess energy disturb the inner equilibrium of the atoms upon impact, forming unstable particles. The excess energy is supplied by the hot sparks or arcing produced by faulty equipment. The production of activated particles increases exponentially with temperature. When the energy released by exothermic reactions exceeds the energy lost by radiation, conduction or diffusion, ignition occurs. The speed of this process is influenced by the rate of energy supplied and the volume of gas to which it is supplied.

Since electrical equipment is an integral and necessary part of the mining process, the simplest solution to this problem, removing the source of energy, is not possible. However, techniques have been developed that isolate the electrical equipment and permit their safe operation in gaseous coal mines (see Section 5.0 of this report).

3.2 Qualification for Intrinsic Safety

Intrinsic safety is a method of protection based on design rather than enclosure. Electrical equipment certified as "intrinsically safe" can operate safely within the hazardous coal mine environment.

CSA Standard C22.2 No. 157, "Intrinsically Safe and Non-incendive Equipment for Use in Hazardous Locations," defines intrinsically safe to mean "...any spark or thermal effect that may occur in normal use or under any conditions of fault likely to occur in practice, is incapable of causing an ignition of the prescribed flammable gas, vapour or dust."

Equipment is made intrinsically safe by limiting the energy that can be released by an electrical circuit to below the minimum ignition level of the hazardous gas or vapour present. This involves limiting the voltage, current, inductance and capacitance of the entire electrical circuit.

Intrinsic safety as a method of protection for electrical equipment in coal mines, however, involves a great deal more than energy limitation. The CEAL and mining authority cite CSA Standard C22.2 No. 157 as the applicable standard for this method of protection (see letters, Appendix D). Examination of this standard will uncover sixteen other applicable standards which must also be considered (Appendix E).

The search for I.S. qualified components, described in detail in Section 2.0 of this report, was frustrated by a lack of commercially available products. As this possibility had been foreseen, it was decided to examine the feasibility of qualifying components through modifications to existing designs. The products of VALCO and SENTEX were chosen as the best potential candidates for certification.

3.2.1 CEAL Certification

Electrical equipment destined for use in underground coal mines must first obtain proper certification from the Canadian Explosive Atmospheres Laboratory, a division of Energy Mines and Resources Canada. The CEAL offers certification and testing services for equipment intended for use in gaseous mines.

Once certification has been granted by the CEAL, equipment must obtain further approval from the mining authority who has jurisdiction over the particular mine involved. For Cape Breton coal mines, the mining authority is the Chief Inspector of Mines for Labour Canada, A.D. Oliver. Although final approval is contingent on acquiring certification from the CEAL, the mining authority reserves the right to refuse approval or make it subject to additional considerations.

3.2.2 The CSA Standards

The foundation of the certification/approval process is the Canadian Standards Association. These standards form the basis of the testing/qualification procedure carried out by the CEAL. Equipment designed or modified in strict accordance with the applicable CSA standards should obtain the approval of the CEAL.

The CSA standards are subjective documents written more as guidelines than rigid requirements. Misinterpretation of the guidelines can result in improperly designed equipment that fails to pass CEAL's testing process. Thus, the design process can be lengthy and time consuming, often requiring several years of testing and re-design before certification is obtained.

The Manager and Certification Officer of the CEAL, John Bossert, was consulted with respect to CEAL's intrinsic safety requirements for

electrical equipment in coal mines. It was ascertained that the certification requirements of the CEAL are those contained in CSA standard C22.2 No. 157 (see letter in Appendix D). Closer examination of this standard, however, reveals sixteen other applicable standards that must be considered as well.

A.D. Oliver, Chief Inspector of Mines for Labour Canada, was also consulted in regard to specific requirements for the operation of an intrinsically safe instrument package in the Cape Breton mine. In his reply, Mr. Oliver stressed the need for CEAL certification in addition to considerations of construction material, the site and conditions under which the instrument is intended, and the person responsible for the instrument (see letter in Appendix D).

The requirements for intrinsic safety that are given in CSA Standard C22.2 No. 157, "Intrinsically Safe and Non-incendive Equipment for Use in Hazardous Locations", are summarized in Appendix E. A flow chart is used to highlight the specific requirements and other standards that apply (16 in all).

It should be noted that the CSA Standard requires considerations of all aspects of the components design. This includes the following:

- construction material
- circuit board coatings
- component spacing
- power requirements
- electrical parameters.

In conclusion, to evaluate a piece of equipment for intrinsic safety according to the CSA Standard, detailed knowledge of all aspects of its construction is required.

4.0 EVALUATION OF COMMERCIAL COMPONENTS

The unsuccessful outcome of the search for commercially available, intrinsically qualified components led to a re-evaluation of the original work mandate. It was decided that in the absence of suitable I.S. qualified components, two options would be pursued:

(1) The feasibility of qualifying non-I.S. components, through modifications to existing designs, would be examined.
(2) If option (1) proved to be unacceptable, the use of explosion-proof enclosures would be considered.

4.1 Selection of Components for Evaluation

In consultation with the Scientific Authority it was also decided to limit the list of potential suppliers to three companies: VALCO, SENTEX and RAPCO. Of the mail survey respondents, the products of these companies were considered the best candidates for the instrument package.

VALCO was selected for two of its stand-alone components:

(1) a high frequency, linear response electron-capture detector
(2) a digital valve sequence programmer.

SENTEX manufactures an instrument package, the size of a briefcase, complete with a TOSHIBA 1100 laptop computer. All the system requirements except for intrinsic safety are incorporated in this design.

RAPCO, a British electronics supplier, carries the only I.S. qualified components uncovered in the survey; a strip chart recorder and data logger. Since the British standards are recognized and accepted by the CEAL, no modifications would be necessary to these products.

The product information from the three companies is included in Appendix F. A copy of the operating manual for RAPCO's data logger has been given to the Scientific Authority.

4.2 Results of Evaluation

To qualify a component by design modifications it is essential to secure all necessary technical information about that component from the supplier/manufacturer. Without complete knowledge of such factors as construction materials, circuit board coatings, spacings between component parts, power requirements, etc., it is not possible to qualify a device to meet intrinsic safety standards. In this case, the applicable standard as set down by the qualifying authority, (the CEAL), and the mining authority, A.D. Oliver, is CSA C22.2 No. 157 (see letters, Appendix D).

Solicitation of VALCO and SENTEX for technical information on the products of interest met with resistance. SENTEX, the manufacturer of the portable GC/ECD unit, maintains that the technical manuals are currently under revision and therefore not available to us. Furthermore, SENTEX officials expressed grave concerns about the feasibility of re-designing their product to meet intrinsic safety standards. A team of SENTEX engineers required three years to modify another product for intrinsic safety and, in the end, was not successful. VALCO provided some schematics for their ECD and digital controller.

On a related note, the GC developed by the Scientific Authority failed to qualify for CEAL certification. Further modification of the unit was not encouraged.

4.3 Conclusions

It was recognized that proprietary concerns may have been the obstacle to disclosure of the requested information. Thus, ANSL offered to sign any documents of non-disclosure required by VALCO and SENTEX. However, this did not result in the release of any additional material.

Without the detailed information required, re-design of the components to meet intrinsic safety standards is simply not possible.

5.0 ALTERNATIVE METHODS OF PROTECTION

The CEAL recognizes two alternative methods of protection for electrical equipment in gaseous mine environments. The difficulties encountered with intrinsic safety qualification necessitated an investigation of these options.

5.1 Explosion-Proof Enclosures

Explosion-proof enclosures are the traditional method for protection of electrical equipment in coal mines. Although CSA standards permit the use of enclosures made from metals other than light-weight alloys in gaseous mine environments, mining authorities prohibit the use of exposed aluminum as well (Appendix D, Oliver's letter). Only explosion-proof enclosures of cast-iron construction have been permitted in coal mines.

George Lobay, certification officer at the CEAL, was contacted to clarify the prohibition of 'exposed' aluminum. Mr. Lobay cited the only written reference to the use of non-exposed aluminum, a paragraph in CEAL's promotional brochure, "Certification and Testing Services for Equipment and Materials for Use in Gaseous Mines, Non-gaseous Mines and Other Hazardous Locations." In Section 2.4 on the use of exposed aluminum or light alloys, mention is made of "exceptional circumstances" under which the use of aluminum is permitted:

> "In exceptional circumstances the use of aluminum is permitted where alternative non-aluminum substitutes are not available. In such cases a substantial guard made from steel or other suitable materials, acceptable to EMR, may be permitted to be used. Components so protected shall also not be located in areas subject to impacts."

Further conversation with Mr. Lobay revealed details surrounding this exception to the rule. The CEAL will qualify aluminum boxes if they are covered by an approved material or coating which cannot break, crack or in any way cause the exposure of the aluminum underneath. The exact properties of the protective covering are not given in any Standard but are left to the discretion of the CEAL.

Aluminum explosion-proof enclosures are preferable to cast-iron boxes because of the requirement for portability. A cast-iron enclosure of the dimensions required to house either the SENTEX unit (Scentograph) or a combination of VALCO stand-alone units, would weigh in excess of 350 pounds (not including the components). Since portability is a crucial consideration in the movement of the system in and out of the mine, cast-iron enclosures are not desirable.

Explosion-proof enclosures can be considered a viable method of protection, providing portability as well, if covered aluminum is the construction material.

5.2 Pressurized Enclosures

Pressurized enclosures offer a second design alternative to intrinsic safety. Although this is not an accepted method for providing protection in mines, failure of the two standard techniques has made its consideration necessary.

Pressurization of electrical equipment is permitted in the Canadian Electrical Code by Rule 18-066. Employment of this technique requires the permission of the local electrical inspection authority. Although the CSA has no guidelines governing this special case, the CEAL recognizes IEC Publication 79-2 (based on NFPA No. 496) as the applicable standard (see letter, Appendix D).

Pressurization as a method of protection involves, "...purging an enclosure with clean air or inert gas at sufficient flow and pressure to reduce to an acceptably safe level the concentration of any flammable gases initially present, and to maintain this safe level by positive pressure" [NFPA No. 496-6 Section 1-4].

Investigation of pressurization as an alternative method of protection was not encouraging. This technique involves extensive additional circuitry and re-design that would complicate the original system considerably.

In brief, the NFPA requirements include the following:

1. Automatic shutdown system with backup.
2. Timing circuitry for purging operation.
3. Maintenance of positive pressure inside enclosure.
4. Pressure monitoring devices able to trigger shutdown system.
5. Audible alarms and visual warning devices.
6. Control circuitry.
7. Automatic door lock.
8. Purging mechanism and blowers.

A complete list of NFPA requirements is given in Appendix F.

A pressurized enclosure is a possible method of protection for a small portable instrument package. The extensive requirements of this technique, however, would encumber and complicate the system considerably. Developing a pressurized enclosure that is consistent with the NFPA or IEC requirements provides no assurance that the CEAL would certify the design. There is no 'standard' approach to certifying such a system and it is not recommended by the CEAL.

6.0 SUMMARY AND RECOMMENDED DESIGN

A survey was conducted to identify commercially available components that could be used in the construction of a gas chromatograph for tracer gas detection in coal mines. The following components are recommended for the final design:

Data Logger: - A data logger, (Rapilog), marketed by RAPCO has been certified as intrinsically safe by British authorities.

Electron-capture Detector: - VALCO markets a stand-alone ECD that can be readily used in gas chromatography systems. This detector is not I.S. certified.

Valve Controller: - VALCO also markets a valve controller that can be used in the instrument package. It is not I.S. certified.

The above components would be used with the portable gas chromatograph designed by the Scientific Authority.

A possible alternative is a complete instrument package marketed by SENTEX. The 'SCENTOGRAPH' incorporates a gas chromatograph and ECD with a TOSHIBA 1100 laptop computer for data acquisition and control. This unit is not certified as intrinsically safe.

Three methods of protection have been considered as a means of making a 'safe' instrument package for service in a coal mine. The advantages and disadvantages of the three methods are given below.

I.S. Qualification

The main advantages of designing an instrument package that is intrinsically safe are:

- portability, since little additional material is added to the package
- access and ease of use of the instrument components
- 'Intrinsic safety' is a passive approach to safety, providing an assured level of protection.

The main disadvantage of designing an instrument package that is intrinsically safe is:

- The level of qualification requires consideration of all details of the design. This in turn requires detailed information on the existing design that is not readily available.

Explosion-Proof Enclosures

The main advantage of designing a safe instrument package through the use of an explosion-proof enclosure is:

- There is no need to re-design the instrument components.

The main disadvantage of using an explosion-proof enclosure is:

- The mass of the enclosure grows very quickly with the volume to be enclosed. This reduces the portability of the system.

Pressurized Enclosures

The main advantage of designing a safe instrument package through the use of a pressurized and continuously purged enclosure is:

- The enclosure does not need to be as massive as in the case of an explosion-proof enclosure. Thus, there is potential for more portability.

The main disadvantage of using pressurized enclosures:

- The protection is provided by an active process of continuously purging the enclosure. There has to be extensive backup systems and protective features to provide protection in the event of a failure of the purge flow.

Recommended Design

It is recommended that the instrument package be made safe by the use of explosion-proof enclosures.

To make the system as portable as possible, the enclosures should be of aluminum construction encased in a suitable material such as zinc. Furthermore, the separate components should have their own enclosures with the modules connected by qualified cabling.

Aluminum CSA-approved enclosures are commercially available in Canada from:

ELECTROLINE MANUFACTURING CO. LTD.
P.O. Box 592, N9A 6M6
1305 Windsor Avenue
Windsor, Ontario N8X 3L8.

These enclosures are designed for electrical/control equipment and do not normally possess the penetrations required for gas chromatography (i.e. sample and vent lines). However, custom-designed enclosures are available and will accommodate the necessary penetrations. (Product information is included in Appendix H).

The internal tubing to these penetrations will have to meet the explosion-proof criteria (i.e. repeated internal explosions will not cause the tubing to fail). This requirement is critical since the penetrations introduce a pathway for exploding gases to reach the outside if the integrity of the tubing is compromised.

All dials, buttons and switches necessary to access during operation of the equipment can be fitted with a corresponding explosion-proof dial, button or switch accessible from the box surface. The manufacturer can also install glass windows to allow viewing of any necessary displays or readouts.

It will be easier to obtain approval for the use of coated aluminum if the instrument is attended at all times. The purpose for this is to prevent the striking of the boxes by metal equipment being used in the mine. If the instrument is unattended, then a suitable guard or shield will have to be placed around the instrument to preserve the integrity of the coating.

The most portable system configuration is achieved by separating the components into two enclosures:

Box 1 - contains the GC's valving and plumbing, bottled gases and detector.

Box 2 - contains the valve controller, ECD control unit, battery and dc-dc converter.

Figures 1 and 2 illustrate the best arrangement of components for minimizing box size.

The following design notes correspond to the assemblies of Figures 1 and 2:

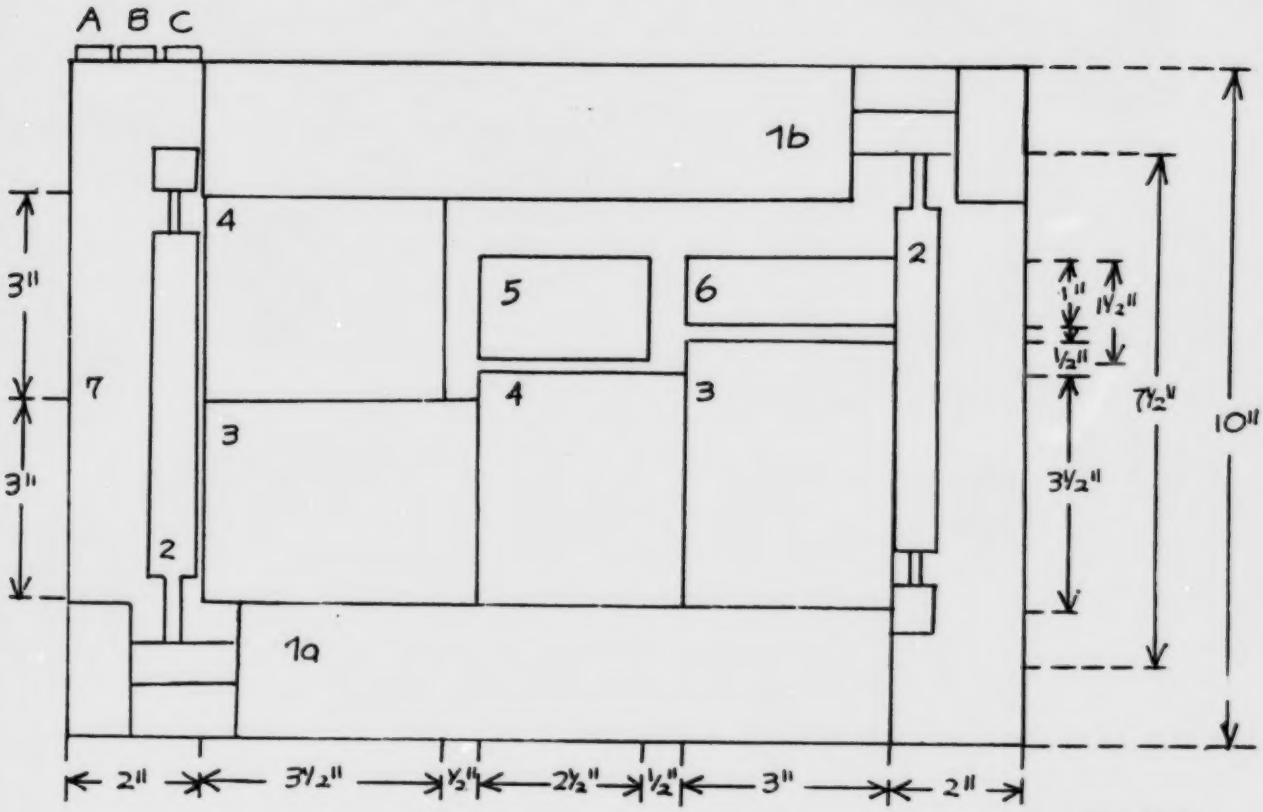
1. The detector of Figure 1 has been removed from the manufacturer-supplied case. The actual detector size is estimated as l = 3", d = 1½".

2. The GC's columns and tubing are not shown in Figure 1 for reasons of clarity. In assembly, this plumbing can be fitted in the space around the other components.

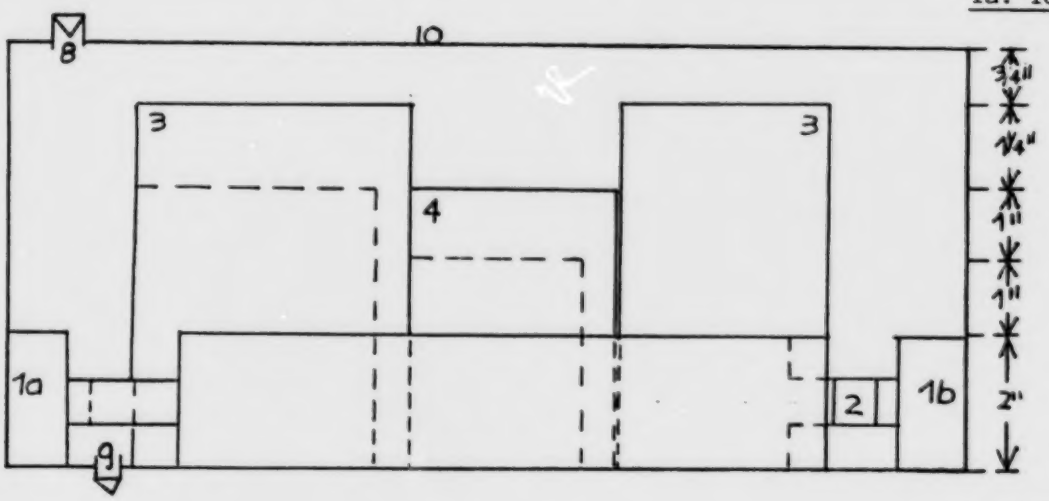
3. The sample inlet line of Box 1 must be explosion-proof. We recommend 1/8" stainless steel tubing with a flame arrestor in line.

4. A mounting plate is recommended to secure all components in place. It will also ease in the removal of the components from the enclosure.

FIGURE 1: BOX #1, SHOWING TOP AND SIDE VIEWS



1a. TOP VIEW



1b. SIDE VIEW

SCALE: 1 cm = 1 inch

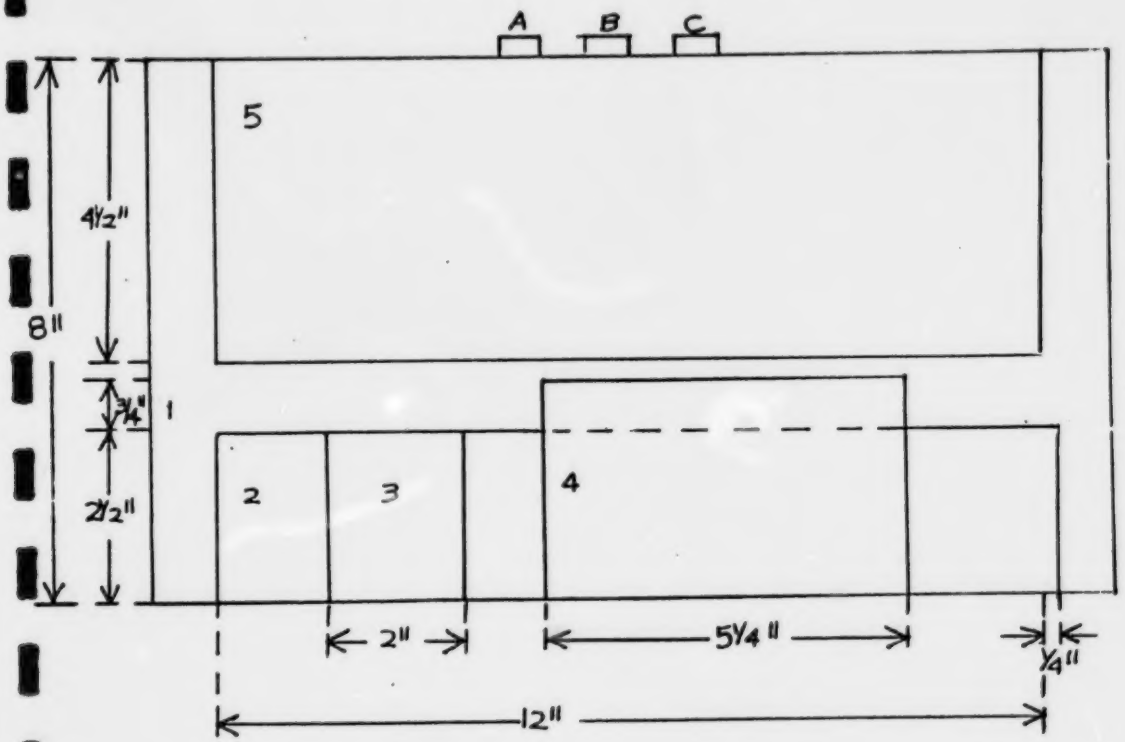
KEY: (NEXT PAGE)

KEY TO FIGURE 1:

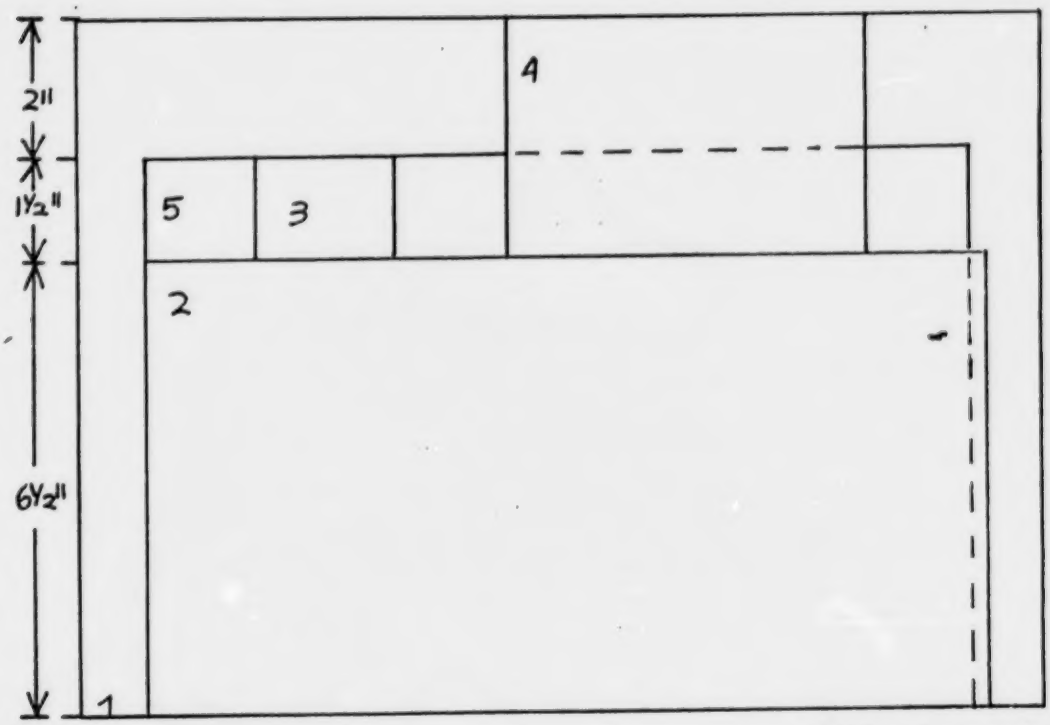
1 LECTURE BOTTLE
  a COMPRESSED AIR
  b CARRIER GAS
2 DUAL STAGE REGULATOR
3 VALVE
4 RELAY (12V)
5 SAMPLE PUMP
6 DETECTOR*
7 MOUNTING PLATE
8 SAMPLE PORT**
9 VENT (EXPLOSION-PROOF)
10 EXPLOSION PROOF ENCLOSURE
A 2-WIRE CABLE FROM SAMPLE PUMP TO BATTERY
B 4-WIRE CABLE FROM RELAYS TO VALVE CONTROLLER
C 3-WIRE CABLE FROM DETECTOR TO ECD CONTROL UNIT

* WITH MANUFACTURER'S CASING REMOVED
** WITH FLAME ARRESTOR IN LINE

FIGURE 2: BOX #2, SHOWING TOP AND SIDE VIEWS



2a. TOP VIEW



2b. SIDE VIEW

KEY:
1 MOUNTING BOARD
2 VALVE CONTROLLER
3 DC-DC CONVERTER
4 BATTERY
5 ECD CONTROL UNIT

SCALE: 1 cm = 1 inch

APPENDIX A

Statement of Work

APPENDIX "A"

STATEMENT OF WORK

TITLE: DESIGN OF AN INTRINSICALLY SAFE INSTRUMENT PACKAGE FOR A PORTABLE GAS CHROMATOGRAPH

REQUIREMENT

On behalf of the Department of Energy, Mines and Resources to design by March 1, 1988 a portable, self-contained, intrinsically safe instrument package for a portable gas chromatograph utilizing an electron capture detector. The unit shall consist of a control unit for the electron capture detector, a data acquisition system and a valve sequence programmer.

BACKGROUND

Tracer gas techniques are now finding increasing application in resolving mine ventilation problems that are difficult to resolve with traditional airflow measuring instrumentation (e.g. anemometers, pitot tubes and smoke tubes). The Cape Breton Coal Research Laboratory routinely uses SF_6 as a tracer gas in ventilation studies of mine ventilation systems. They have developed in-house a portable gas chromatograph which is capable of determining trace levels of SF_6 in air every 10 seconds. This instrument has been tested in an arduous underground mining environment and proved to be a valuable tool. In its present state this gas chromatograph cannot be used in a gaseous underground coal mine. The instrument does not comply with the requirements of the Canadian Explosive Atmospheres Laboratory (CEAL) for intrinsic safety.

The purpose of this contract is to identify commercially available components which either comply with the necessary standards or could be easily modified to do so. Then using the most appropriate components, design a permissible instrument package for the gas chromatograph.

STATEMENT OF WORK

1. Through a literature review, correspondence and telephone conversations review the commercially available components which could find application for the system as described below. The system should be capable of:

   a) real-time operator monitoring of pertinent parameters,

   b) automatic unattended operation with manual override,

   c) accurate performance when operated at ambient temperatures,

   d) being operated with either nitrogen or argon/methane as a carrier gas,

   e) precision control of a minimum of two switching valves (minimum of four intervals required),

   f) accurate measurement and storage of a SF_6 peak of 250 msec width (consideration must be given to monitoring the frequency or pulse-train output of the electron capture detector using a pulse-counter instrument),

   g) sufficient data storage for a minimum of five hours of continuous operation or 1800 peaks, and

   h) facilitating the transfer of the stored data to an IBM-PC/AT micro-computer (all necessary hardware and software should be included).

2. In consultation with the Scientific Authority select the most suitable components and submit a report with complete design drawings for the system by March 1, 1988.

REPORTS

The final report in ten (10) copies, is to be submitted at the conclusion of the work and this report must be comprehensive dealing with all facets of the work and must include sufficient drawings, sketches, photographs and discussions of problems and successes associated with the work to facilitate a full accurate evaluation of the work by the Scientific Authority. This report will be prepared in accordance with good engineering practice and will include as a minimum the following format: executive summary, introduction, discussion, conclusions and supporting graphs, tables and figures. The executive summary will be in both English and French. The report shall be subject to inspection by the Scientific Authority prior to acceptance and should it not be in accord with this contract, the Scientific Authority shall have the right to reject it or require its modification.

APPENDIX B

List of Suppliers

The following 58 companies were contacted in the initial mail survey for possible components of interest. A copy of this letter is included.'R' indicates initial respondents. 'F' indicates companies sent second letters requesting additional information.

1. B.J. POROUS PRODUCTS — R
   1262 Don Mills Rd.
   Suite 17
   Don Mills, Ont.
   M3B 2W7

2. LABSERCO LTD. — R,F
   1100 Invicta Dr.
   Unit 8
   Oakville, Ont.
   L6H 2K9

3. R.H. NICHOLS CO. LTD.
   80 Vinyl Ct.
   Woodbridge, Ont.
   L4L 4A3

4. ROSEMOUNT INSTRUMENTS LTD.
   235 Watline Ave.
   Mississauga, Ont.
   L4Z 1P3

5. TRACOR NORTHERN CANADA — R,F
   116 Galaxy Blvd.
   Rexdale, Ont.
   M9W 4Y6

6. ACE SCIENTIFIC SUPPLY CO.
   40-A Catters Lane
   East Brunswick, NJ
   08816

7. ANALYTICAL INSTRUMENT DEVELOPMENT, INC.
   Rt. 41 & Newark Rd.
   Avondale, PA
   19311

8. ANSPEC COMPANY INC. — R
   P.O. Box 7730
   Ann Arbor, Michigan
   48107

9. BASELINE INDUSTRIES INC.
   P.O. Box 649
   North Star Route
   Lyons, CO
   80540

10. BIO-RAD, DIGILAB DIVISION
237 Putnam Ave.
Cambridge, MA
02139

11. BYRON INSTRUMENTS INC. R
520 S. Harrington St.
Raleigh, NC
27601

12. DANIEL INDUSTRIES
9720 Katy Rd.
Houston, Texas
77024

13. DIGICOLOR INC.
2770 E. Main St.
Columbus, Ohio
43209

14. THE FOXBORO COMPANY R
96 Neponset Ave.
Foxboro, MA
02035

15. GIBSON MEDICAL ELECTRONICS INC.
P.O. Box 27
Middleton, NJ
53562

16. GOW MAC INSTRUMENT CO. R
International Scientific of Canada
P.O. Box 6220, Station J
13084 Wellington St.
Ottawa, Ont.
K2A 1S6

17. HNU SYSTEMS INC. R,F
160 Charlemont St.
Newton, Mass.
02161

18. HACH COMPANY R
P.O. Box 389
Loveland, Colorado
80539

19. KRATAS ANALYTICAL, DIVISION SPECTRAS INC.
170 Wlliams Dr.
Ramsey, NJ
07446

20. LDC/MILTON ROY
P.O. Box 10235
Riviera Beach, Florida
33404

21. MTI, MICROSENSOR TECHNOLOGY INC.
47747 Warm Springs Rd.
Fremont, CA
94539

22. MICROMERITICS INSTRUMENT CORP.
5680 Gashen Springs Rd.
Norcross, GA
30093

23. NUTECH CORP.
2806 Cheek Rd.
Durham, NC
27704

24. ORGANOMATION ASSOCIATES INC. R
266 River Rd. W.
Box 159
S. Berlin, MA
01549

25. PCP, INC.
2155 Indian Rd.
West Palm Beach, Florida
33409-3287

26. PERKIN-ELMER CORP. R
Main Ave.
Norwalk, CT
06856

27. PROCESS ANALYTICS, A DIVISION OF COMBUSTION ENGINEERING R
P.O. Drawer 831
Lewisburg, WV
24901

28. PROCESS ANALYZERS INC.
8 Headley Pl.
Fallsington, PA
19054

29. RAININ INSTRUMENT CO. INC.
Mack Rd.
Woburn, MA
01801

30. S-CUBED, A DIVISION OF MAXWELL LABORATORIES INC. R,F
P.O. Box 1620
La Jolla, CA
92038

31. SADTLER RESEARCH LABS R
A Division of Bio-Rad Lab Inc.
3316 Spring Garden St.
Philadelphia, PA
19104

32. TECHNICAL ASSOCIATES
7051 Eton Ave.
Canoga Park, CA
91303

33. TRACOR, INC. R
Instruments Division
9441 Baythorne
Houston, Texas
77041

34. VARIAN ASSOC., INC. R,F
Instrument Group
220 Humboldt Ct.
Sunnyvale, CA
94089

35. XONTECH, INC. R
6862 Hayvenhurst Ave.
Van Nuys, CA
91406

36. VALCOR ENGINEERING CORP. R
2 Lawrence Rd.
Springfield, NJ

37. FINNAN ENGINEERED PRODUCTS R
1149 BellamyRd. N.
Unit 22, Scarborough, Ont.
M1H 1H7

38. MATHESON GAS PRODUCTS R
P.O. Box 89
Whitby, Ont.
L1N 5R9

39. SENSIDYNE R
12345 Starkey Rd.
Suite E.
Largo, Florida
33543

40. VALCO INSTRUMENTS CO., INC. — R,F
P.O. Box 55603
Houston, Texas
77255

41. SENTEX SENSING TECHNOLOGY, INC. — R,F
553 Broad Ave.
Ridgefield, NJ
07657

42. METRABYTE — R
440 Myles Standish Blvd.
Taunton, MA
02780

43. ASOLECTRIC LTD. — R
P.O. Box 2548
Dartmouth East Post Office
Dartmouth, Nova Scotia
B2W 4B7

44. TECHNICAL MARKETING ASSOC. LTD. — R
6620 Kitimat Rd., Unit 6
Mississauga, Ont.
L5N 2B8

45. HEWLETT-PACKARD CO. — R,F
Eastern Sales Region H.2., No. 4
Choke Cherry Rd.
Rockville, MD
20850

46. KAYTRONICS
200 Richmond
Ville St. Pierre, Que.
H8R 3Y8

47. RAPCO Electronics Ltd. — R,F
Joule Road, Houndmills
Basingstoke, Hants
England
RG21 2XF

48. TRANSMATION CANADA INC.
170 Brackport Drive
Rexdale, Ontario
M9W 5C0

49.	MINES SAFETY APPLIANCES 99 Rocky Lake Road Bedford Trade Mart Bldg. Bedford, Nova Scotia B4A 2T3	R
50.	ELCON INSTRUMENTS 1994 Moreland Parkway, #8 Annapolis, Maryland 21401	R
51.	INTERTECHNOLOGY INC. 3675 Boul. des Sources Suite 105 Dollard des Ormeaux, Quebec H9B 2T6	R
52.	SEALEVEL SYSTEMS INC. P.O. Box 1808 105 S. Pendleton St. Easley, S.C. 29641	R
53.	NUCLEAR DATA INC. Instrumentation Division Golf and Meacham Roads Schaumburg, Illinois 60196	R
54.	YELLOW SPRINGS INSTRUMENT CO., INC Industrial Division Yellow Springs, Ohio 45387	R
55.	OMEGA ENGINEERING INC. 1 Omega Drive P.O. Box 4047 Stamford, CT 06907	R,F
56.	IBM CANADA LTD. P.O. Box 657 North York, Ontario M3C 2T6	R
57.	QUATROSENSE ENVIRONMENTAL LTD 18-1 Enterprise Avenue Nepean (Ottawa), Ontario K2G 0A6	R

58. MANDEL SCIENTIFIC COMPANY, LTD. R,F
143 Dennis Street
Rockwood, Ontario
NOB 2KO

ATLANTIC NUCLEAR SERVICES LTD. (506) 458-9552

390 KING ST., BOX 1268, STN. A., FREDERICTON, N.B. E3B 5C8

July 17, 1987

MTI, Microsensor Technology Inc.
47747 Warm Springs Blvd.
Fremont, CA
94539

Dear Sir:

I am designing a portable trace gas detection system for use in underground mines. The design will incorporate a gas chromatography unit, an electron-capture detector, and a data acquisition system.

I would appreciate receiving, at your earliest convenience, any information you may have on any or all of the above mentioned components.

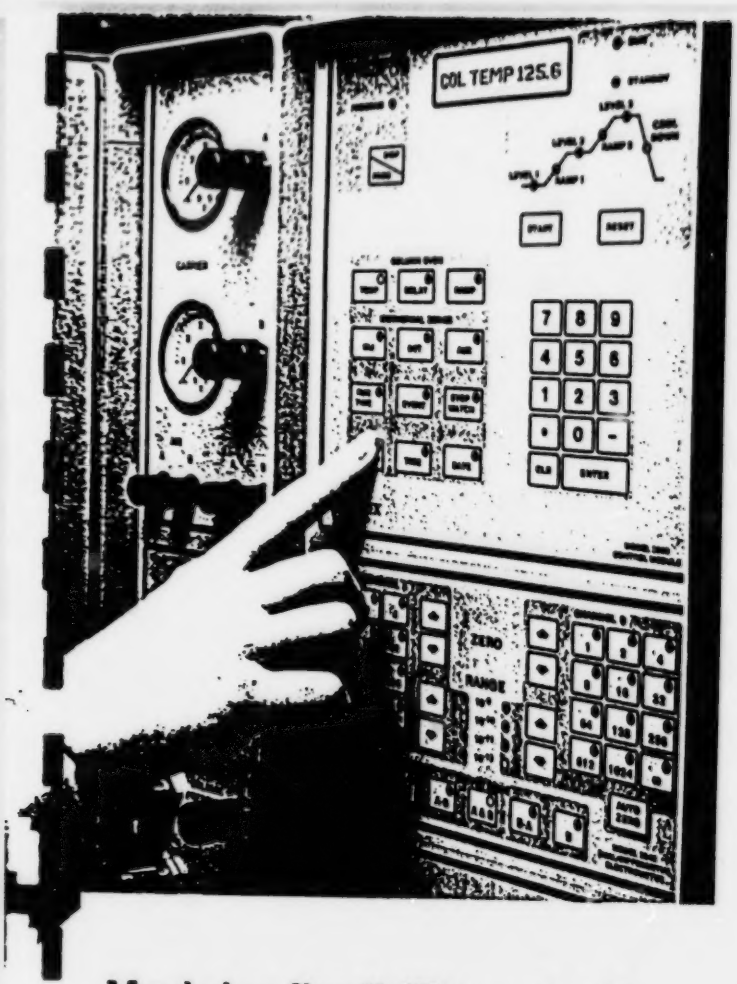
Thank you in advance for your co-operation.

Sincerely,

M.A. Dencer
Project Engineer

APPENDIX C

Sample of Vendor Response



The ANTEK 3000 Gas Chromatograph puts you in control.

At last, the complete control of a gas chromatograph has been placed where it always belonged — in the hands of the chromatographer. ANTEK introduces state-of-the-art simplicity in an instrument so versatile, it can be programmed to your precise specifications at the touch of a finger.

Simple touch pad actuates the built-in microprocessor control functions and analytical parameters.

Lighted display buttons tell you at a glance precisely what conditions are being utilized and the status of the analysis.

Analytical conditions and control functions can be changed at any time by the simple touch of a button.

Your methods can be developed, stored, recalled and used with unprecedented ease.

Modular flexibility — to fit your needs.

ANTEK 3000 GC offers the chromatographer maximum flexibility. Modular design lets you build the exact system you need for virtually any analysis. Just choose the desired combination of detector control modules, power supply modules and flow systems.

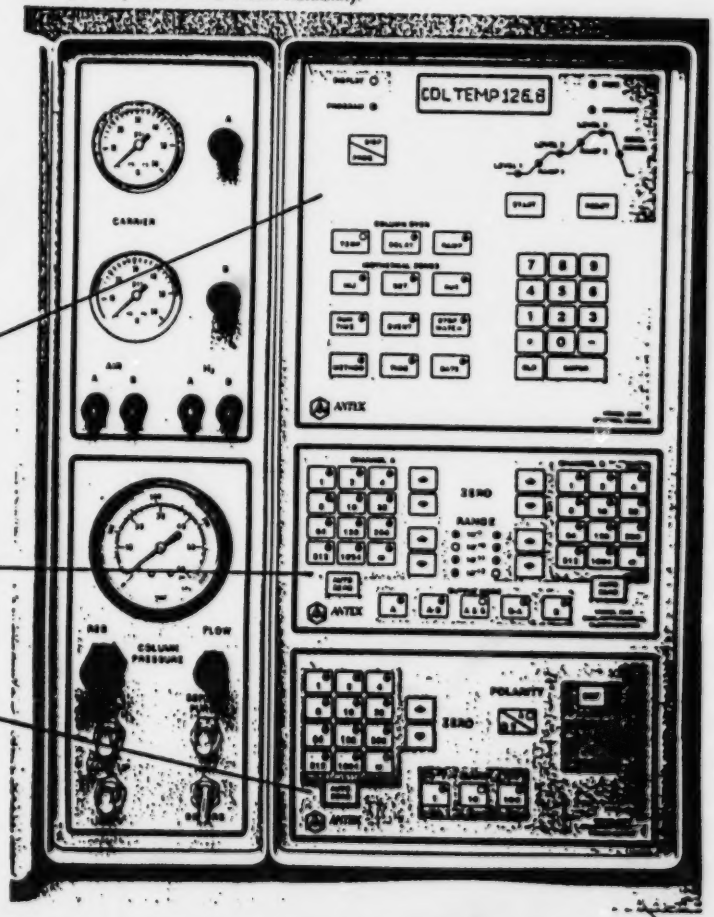
Change the system by simply changing modules.

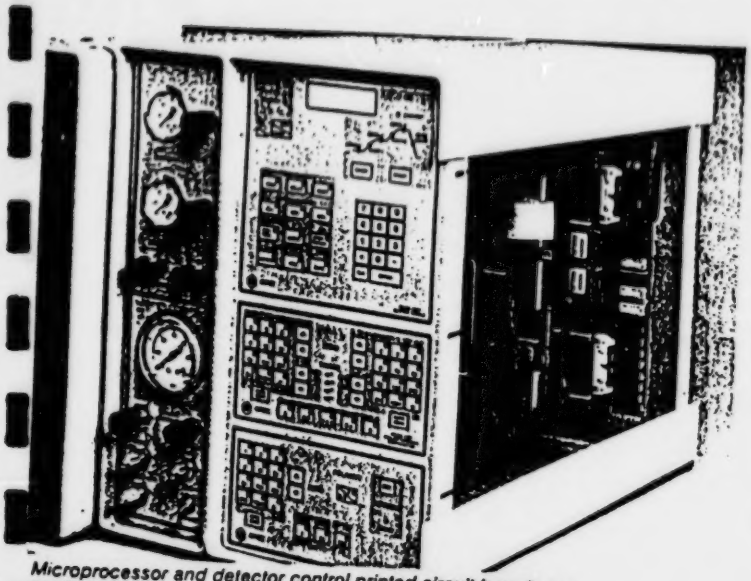
1. Model 3000 Electronic Control Module is the heart of the ANTEK system. It enables the chromatographer to input all temperature parameters — isothermal and programmed, timed events, analytical methods, and numeric values for voltage and current into the microprocessor.

2. Detector Control and Power Supply Modules plug into appropriate control panel positions. Select from four power modules and eight detectors to create the right detection system for your analytical needs.

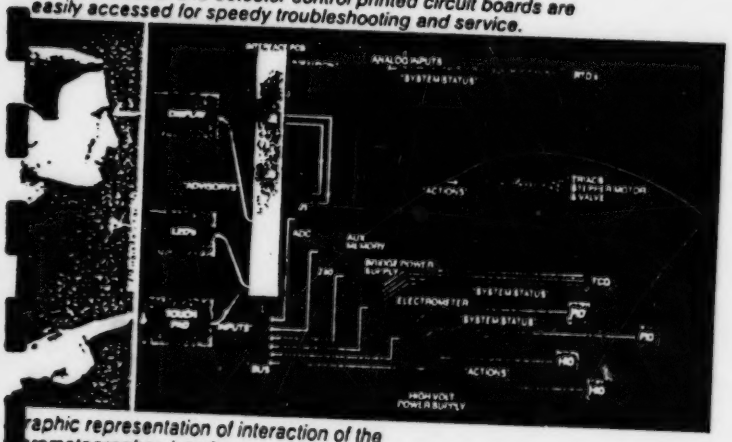
3. Flow Modules offers even more versatility. ANTEK 3000 provides flow systems for thermal conductivity and/or ionization detectors, packed column, capillary or wide bore capability. With ANTEK 3000, the flexibility is built-in.

Modular touch pad front panel and diverse flow panel provide maximum flexibility.





Microprocessor and detector control printed circuit boards are easily accessed for speedy troubleshooting and service.



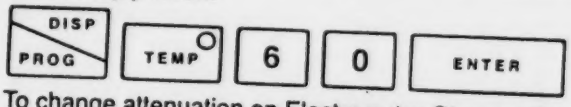
raphic representation of interaction of the romatographer, interface, microprocessor and GC.

Now you can have direct control of GC functions.

Manipulating GC functions has never been so easy. Chromatographic parameters may be changed with as little as one key stroke.

A sealed, easy-touch front panel keypad controls communication with the microprocessor. LED's and intelligent alphanumeric displays guide the chromatographer during programming. The displays also give the status of the system.

For example. To set the column oven temperature to 60°C, simply touch.



To change attenuation on Electrometer Channel B to 64, simply touch:

(in Channel B section)

Setting or changing all parameters is just as easy as demonstrated above. During construction of the temperature programs, the alphanumeric display conveniently guides the chromatographer.

Take a look inside the ANTEK 3000 microprocessor.

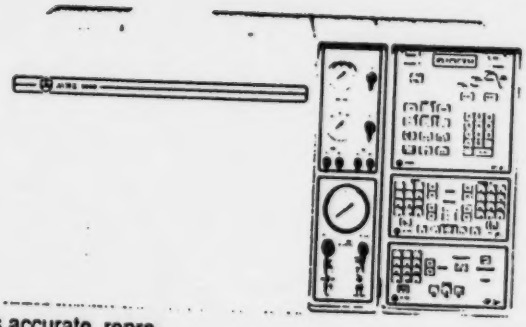
To the left, the diagram describes how the microprocessor works. The chromatographer has direct control of all GC operations through the sealed touch keypad.

As entries are keyed, the microprocessor controls all GC functions. Front panel LEDs reveal system status. The alphanumeric display provides meaningful messages to aid in both programming and trouble shooting.

Microprocessor electronics are housed in replaceable circuit boards for ease of service.

he Oven.

rge column oven gives you maximum flexibility in the selection and placement of inlets, lumns, valves and detectors. ven size specifications are 35.0 cm wide X 24.9 cm high X 22 cm ep (13.8 in. x 9.8 in. x 8.8 in.) h a volume of 19522 cm³ (1190 in.³).



Total microprocessor control provides accurate, reproducible chromatography and activation of sampling and column switching valves. Temperature control software gives precise heating rates and very rapid cooldown (250 °C to 50 °C in just 3.5 minutes).

Component flexibility makes it easy to pick a system to fit your application. Accommodate from 1 to 4 injectors and detectors with 1 to 4 packed columns or up to 4 capillary columns.

Components

Capillary Injectors
1. Cool-on-column
2. Split/Splitless

Packed Column Injectors
3. Flash vaporization
4. On-column

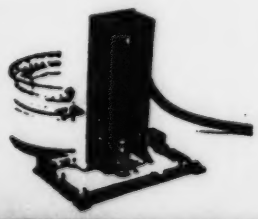
Detectors Installation of up to 4 of the 8 available detectors provides the versatility needed to meet today's demanding analytical tasks. All 8 detectors are compatable with packed or capillary columns.

1. TCD
2. FID
3. HID
4. UPID*
5. FPD
6. TID/CFID
7. ECD
8. CND*

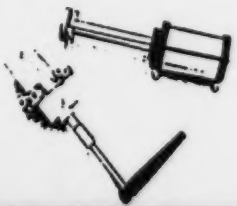
Combined with autosamplers, sample valves, column switching valves, data systems and other accessories, the ANTEK 3000 has the versatility to put you in total control.
*New detector, see specifications.

Options

vel 736-2V Autosampler



Sampling and Column Switching Valves with Automation



Eight detectors available

Model 4270 Chromatography Integrator

ANTEK 3000

Specifications

Column Oven
Size: Height 24.9 cm (9.8 in.)
Width 35.0 cm (13.8 in.)
Depth 22.4 cm (8.8 in.)
Volume: 19522 cm^3 (1190 in^3)
Capacity: up to four 30 ft. metal ⅛" OD columns or;
up to four 10 ft. glass ¼" OD columns or;
up to four 100 m capillary columns.
Temperature Range: 5 °C above ambient to 425 °C. −99 °C to 425 °C with cryogenic option.
Cooldown Rate: 250 °C to 50 °C in 3.5 minutes.

Column Oven Temperature Control
Multilinear Temperature Program: 6 steps
Delay Times: 0 to 650 min. in 0. 1 min. increments
Ramp Rates: 0 to 20 °C/min. in 0.1 °C/min. increments

Isothermal Zones
Temperature Range: Ambient to 425 °C
Six independent isothermal zones are available: two injector, two detector and two auxiliary.

Methods
Storage of 6 methods for exact reproduction of analytical parameters.

Timed Events
Eight programmable events for valve switching or actuation of other accessories.

Injectors
Flash vaporization, cool and heated on-column, ⅛" and ¼", for packed column.
Cool-on-column and split/splitless for capillary columns.

Detectors
Thermal Conductivity (TCD)
Sensitivity: 11 μv/ppm (5 x 10^3 mV-ml/mg) butane at 300 ma, 120 °C, He carrier.
Minimum Detectable Limit: 3 x 10^{-10} g/ml butane.
Linearity: $>10^5$, butane.
Power Supply: constant current, 0 to 300 ma in 1 ma increments, filament protect.
Capillary Option: cell volume 30 μl.
Flame Ionization (FID)
Sensitivity: >0.015 coulombs/g C
Minimum Detectable Limit: 4 x 10^{-12} g/sec.
Linearity: $>10^7$, butane
Noise: 2 x 10^{-14} amperes
Electrometer: Single or Dual/Differential
Helium Ionization (HID)
Generally Licensed: No specific license required.
Minimum Detectable Limit: <20 ppb N_2
<10 ppb CO_2
<10 ppb CH_4
Linearity: $>10^4$
Ionization Source: 190 mc ^3H
Power Supply: 0 to 1200 VDC in 1 volt increments
Electrometer: Single or Dual/Differential
Universal Plasma Ionization (UPID)
Generally Licensed: No specific license required.
Minimum Detectable Limit: <100 ppb for permanant gases and light hydrocarbons
Linearity: $>10^3$
Ionization Source: 190 mc ^3H
Power Supply: 0 to 1200 VDC in 1 volt increments
Electrometer: Single or Dual/Differential
Flame Photometric (FPD)
Minimum Detectable Limit: Sulfur <10^{-10} g/sec.
Phosphorus <10^{-12} g/sec.
Range: Sulfur $>10^3$
Phosphorus $>10^5$
Thermionic Ionization (TID)
Minimum Detectable Limit: 1 x 10^{-13} gN/sec. (azobenzene)
5 x 10^{-14} gP/sec. (malathion)
Linearity: 2 x 10^5 for N
Electron Capture (ECD)
Minimum Detectable Limit: 0.1 picogram Aldrin
Dynamic Range: $>10^5$ for Aldrin
Cell Volume: 180 ul
Operating Temperature: up to 320 °C
Carrier Gas: Nitrogen or Argon/Methane
Chemiluminescent Nitrogen (CND)
Type: Pyro-chemiluminescent, totally specific for nitrogen
Minimum Detectable Limit: <1 nanogram N
Dynamic Range: $>10^5$

Detector Controllers
Electrometer
Used with: FID, HID, UPID, TID
Types: Single input with single output or Dual input with single, dual or dual/differential output.
Sensitivity: 5 x 10^{-13} amperes/millivolt
Attenuator: Binary from 1 to 1024 and infinity.
Auto Zero: Standard
Drift: <10 μv/month at constant temperature.
Output: Recorder 0 — 1 mV
Computer 0 — 1 V
0 — 10 V
Constant Current Power Supply
Used With: TCD, FPD
Range: 0 to 300 ma in 1 ma increments
Amplifier Gain: selectable at 1X, 10X or 100X amplification
Attenuator: Binary from 1 to 1024 and infinity
Auto Zero: Standard
High Voltage Power Supply
Used With: HID, UPID, FPD
Range: 0 to 1200 volts DC in 1 volt increments
Polarity: + and −
Stability: better than 0.002%

Flow System
Carrier:
1) manual flow control
2) optional flow controller with pressure guage
3) optional digital flow controller
Air/H_2:
On/off valves with adjustable metering valves
Filters:
1) optional particulate filters
2) optional H_20/Hydrocarbon filters
Power Requirements
115 VAC 60 Hz 2200 watts
230 VAC 50/60 Hz 2200 watts

Physical
Height: 43.2 cm (17.0 in.)
Width: 78.2 cm (30.8 in.)
Depth: 53.3 cm (21.0 in.)
Weight: 61 kg (135 lbs.)

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APPENDIX D

Safety Requirements for Coal Mines

Labour Canada | Travail Canada

04 December 1987

6009 Quinpool Road
P. O. Box 8628
Halifax, Nova Scotia
B3K 5M3

Ms. Mary Anne Dencer
Project Engineer
Atlantic Nuclear Services Inc.
P. O. Box 1268
Fredericton, N. B.
E3B 5C8

Dear Ms. Dencer:

In response to your letter of November 26, 1987, the "intrinsically safe" design of any instrument intended for use in a Cape Breton coal mine will require certification by the Canadian Explosives Atmospheres Laboratory under the management of Mr. John A. Bossert, located at the CANMET facility of Energy, Mines, and Resources, 555 Booth Street, Ottawa (K1A 0G1). The specific criteria used to determine the intrinsic safety of a design is available from Mr. Bossert who can be reached by telephone at (613) 996-4570.

In addition to the certification process, an approval to use the instrument in the coal mines will have to be obtained from this office by the owners of the Cape Breton coal mine. The granting of an approval would be subject to such considerations as the use of aluminum in its construction as this material is banned, the site and conditions under which the instrument is intended to be used, and who would be responsible for the instrument.

If you require any further information, please do not hesitate to contact me.

Yours truly,

A. D. Oliver, P. Eng.
Chief Inspector of Mines

cc: G. J. Blanchard
T. E. Smales
G. A. Haslett

Canada

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

Mineral and Energy Technology
Technologie des Minéraux et de l'Énergie

CANMET
CANMET

Mineral Technology Branch
555 Booth Street
Ottawa, Canada
K1A 0G1

Direction de la technologie minérale
555, rue Booth,
Ottawa, Canada
K1A 0G1

Telephone: 613-996-4570 ext. 138
Telex : 053-3586 FAX: 613-995-3456
(Answerback: M R BELCOR OTT)

Your file / Votre référence

Our file / Notre référence

December 14, 1987.

Atlantic Nuclear Services,
P.O. Box 1268,
Fredericton, N.B.
E3B 5C8

Attention: Mary Anne Dencer

Dear Ms. Dencer:

Subject: Intrinsically Safe and Pressurized Equipment for Use in Gaseous Mines

In response to your inquiry, our requirements for certification of intrinsically safe equipment for use in underground coal mines are those contained in CSA Standard C22.2, No. 157, gaseous mines category.

For pressurized enclosures, there is no Canadian standard available so that we would use the International Electrotechnical Commission (IEC) publication 79-12. As I pointed out in our telephone conversation, pressurized enclosures are not very common in this application so that we could not guarantee their acceptance. There is also the problem that a "clean" air source is not normally available in a coal mine so that bottled air or inert gas must be used.

If you have any further questions regarding our certification requirements please do not hesitate to contact us.

Yours very truly,

J.A. Bossert, P.Eng.
Manager and Certification Officer
Canadian Explosive Atmospheres Laboratory

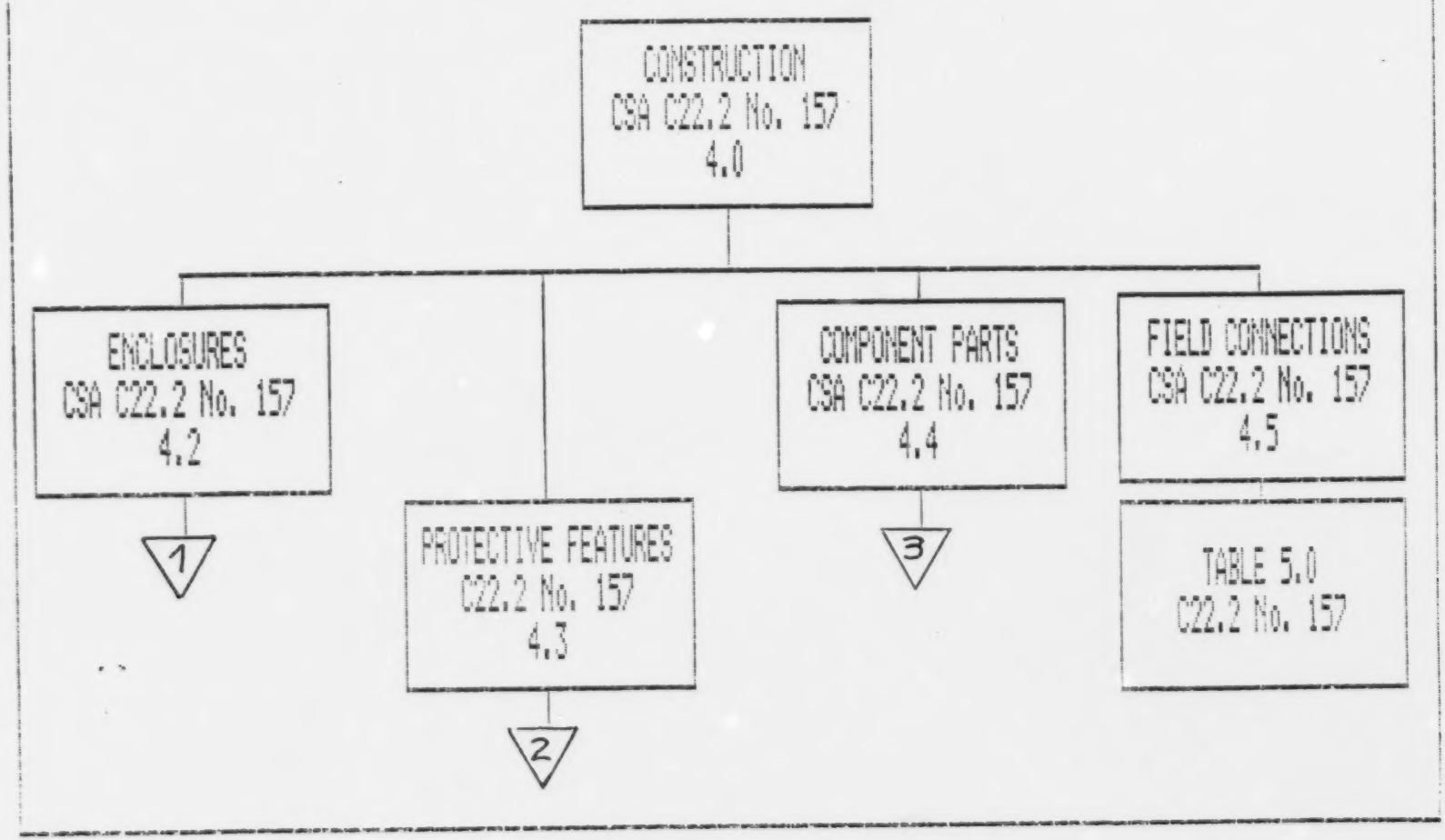
JAB/mmi

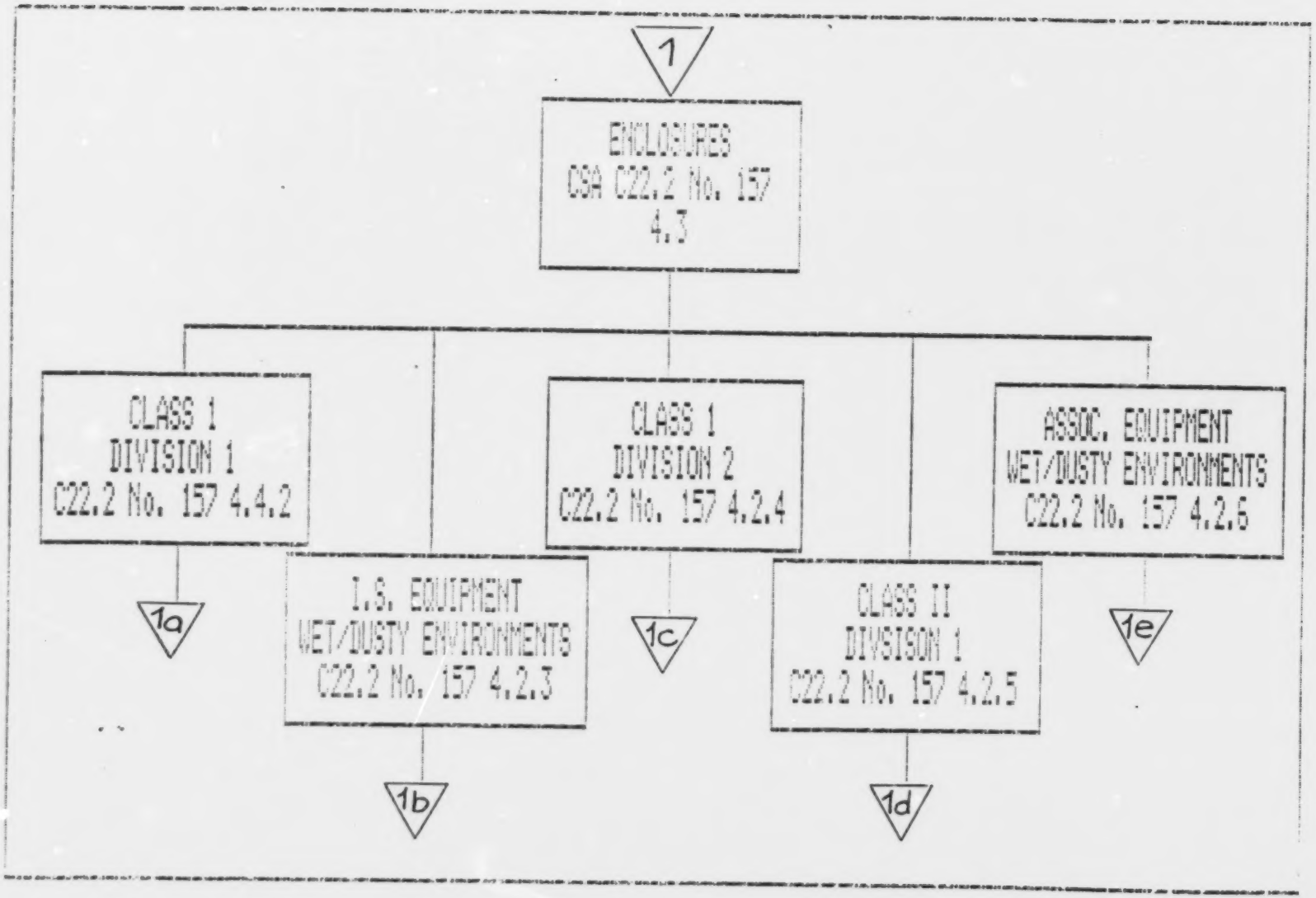
Canada

APPENDIX E

Flowchart of CSA Standard C22.2 No. 157 "Intrinsically Safe and Non-incendive Equipment for Use in Hazardous Locations"

CSA Flowchart based on CSA C22.2 No. 157
Intrinsically Safe and Non-icendive Equipment
for Use in Hazardous Locations

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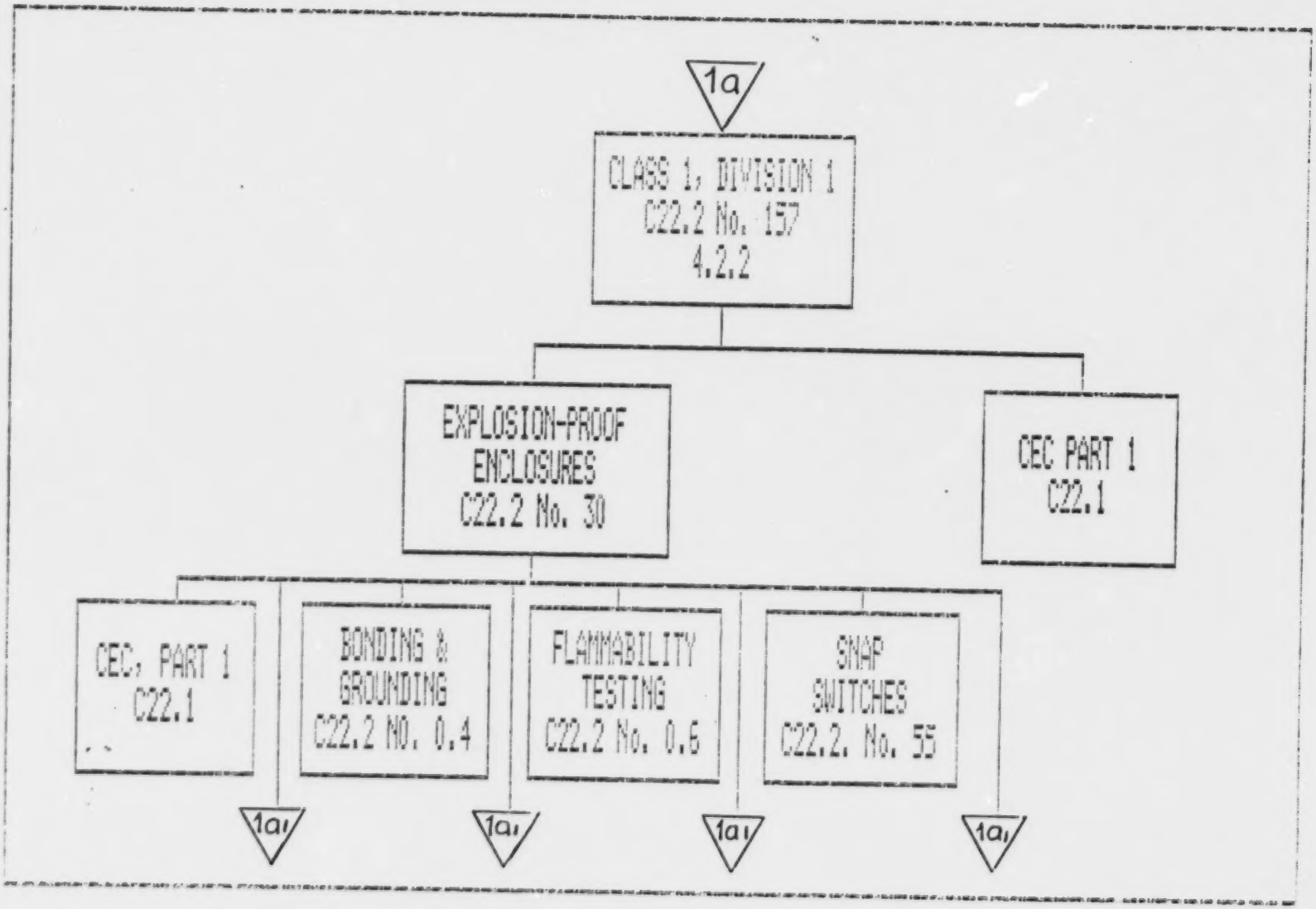
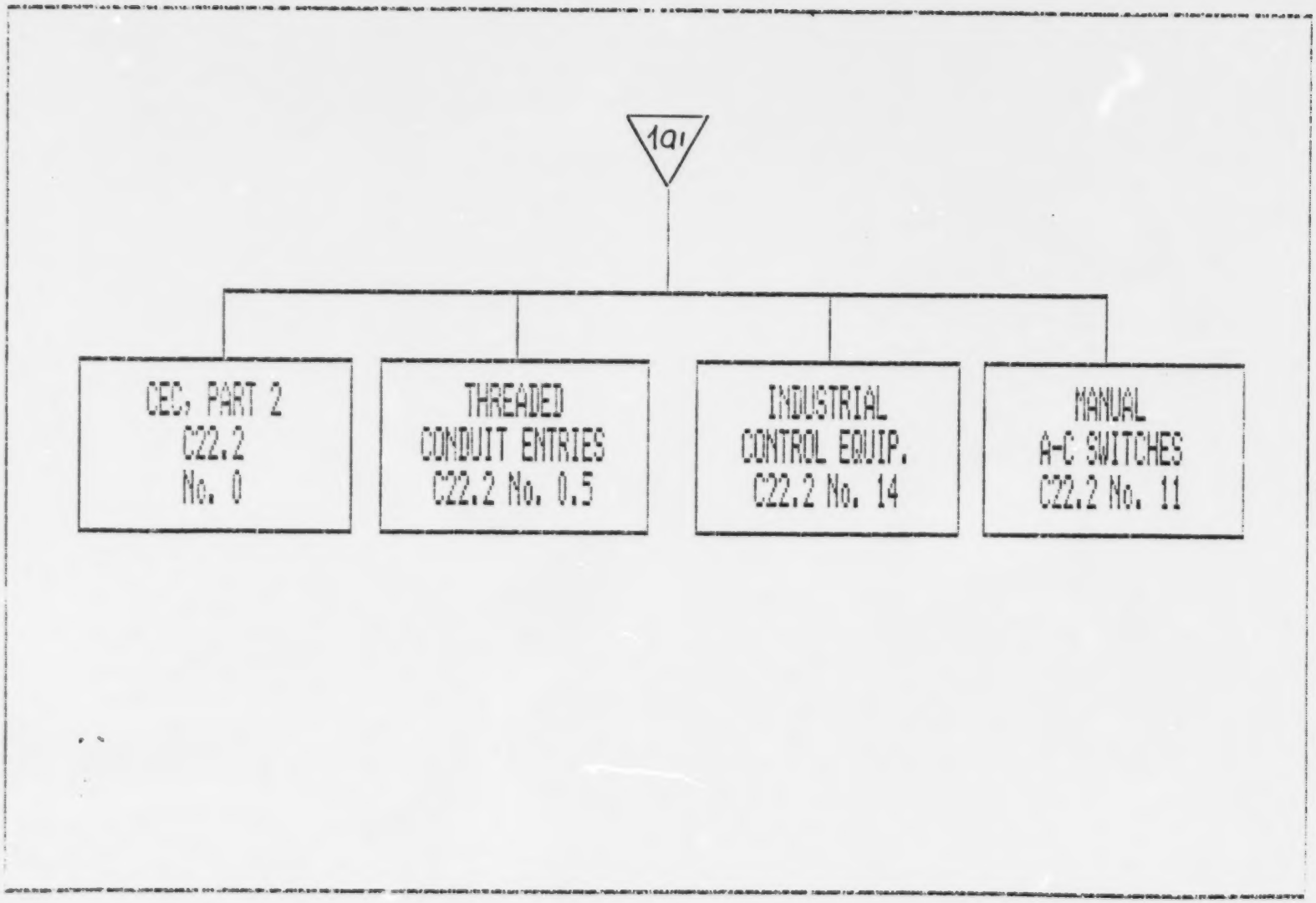
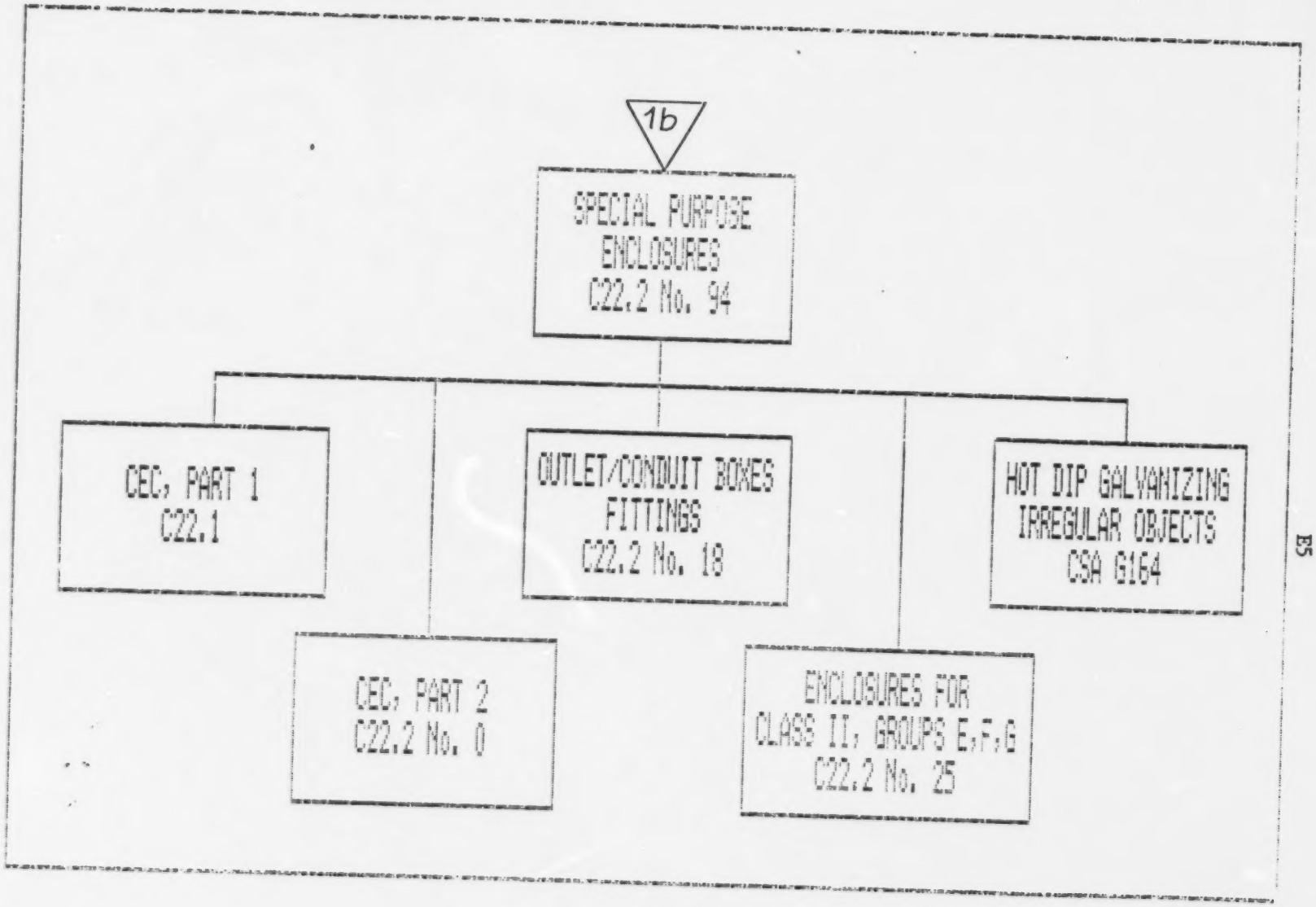
ENCLOSURES
CSA C22.2 No. 157
4.3
CLASS 1
DIVISION 1
C22.2 No. 157 4.4.2
CLASS 1
DIVISION 2
C22.2 No. 157 4.2.4
ASSOC. EQUIPMENT
WET/DUSTY ENVIRONMENTS
C22.2 No. 157 4.2.6
1a
I.S. EQUIPMENT
WET/DUSTY ENVIRONMENTS
C22.2 No. 157 4.2.3
1c
CLASS II
DIVISION 1
C22.2 No. 157 4.2.5
1e
1b
1d


1a
CLASS 1, DIVISION 1
C22.2 No. 157
4.2.2
EXPLOSION-PROOF
ENCLOSURES
C22.2 No. 30
CEC PART 1
C22.1
CEC, PART 1
C22.1
BONDING &
GROUNDING
C22.2 NO. 0.4
FLAMMABILITY
TESTING
C22.2 No. 0.6
SNAP
SWITCHES
C22.2. No. 55
1a
1a
1a
1a


191
CEC, PART 2
C22.2
No. 0
THREADED
CONDUIT ENTRIES
C22.2 No. 0.5
INDUSTRIAL
CONTROL EQUIP.
C22.2 No. 14
MANUAL
A-C SWITCHES
C22.2 No. 11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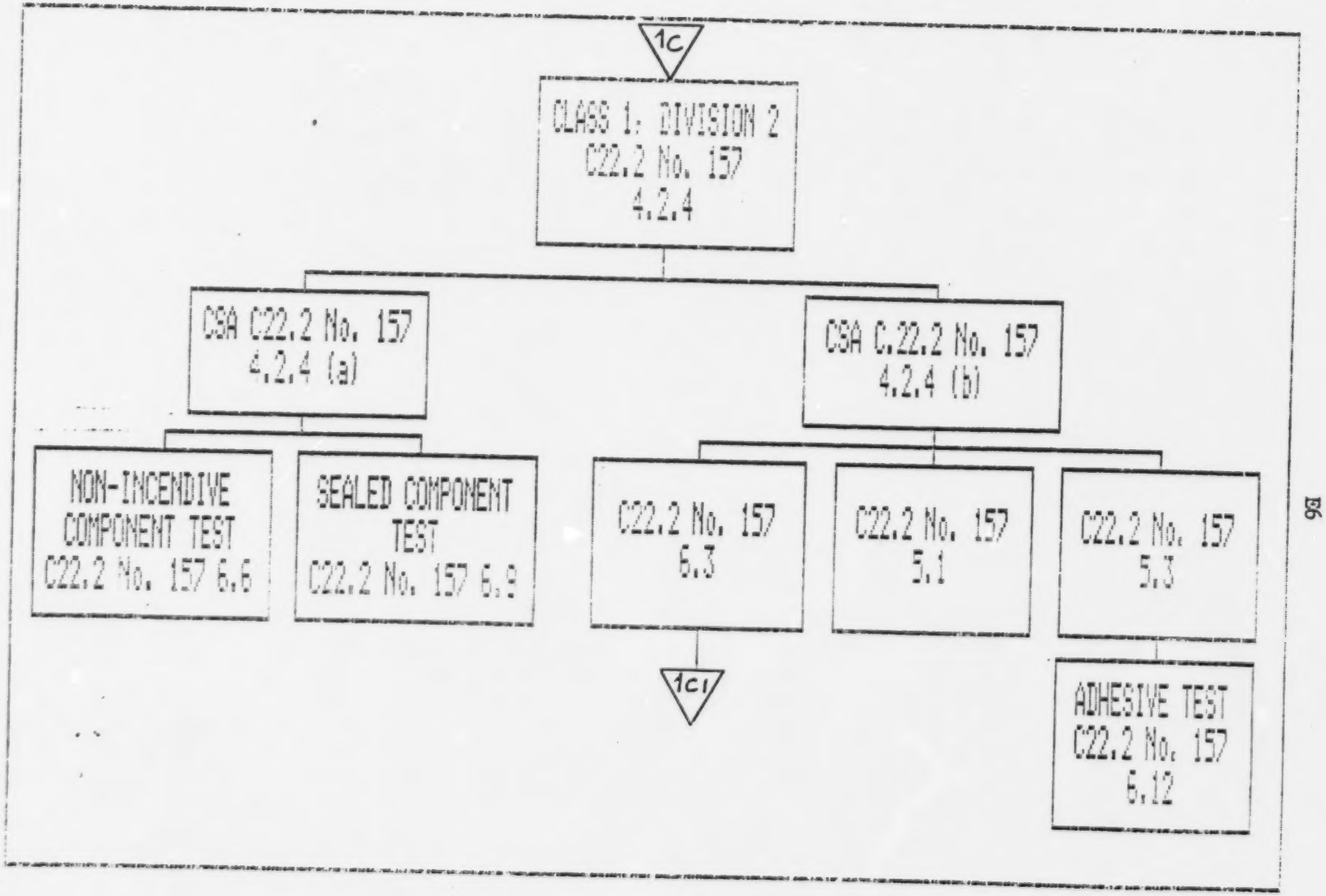
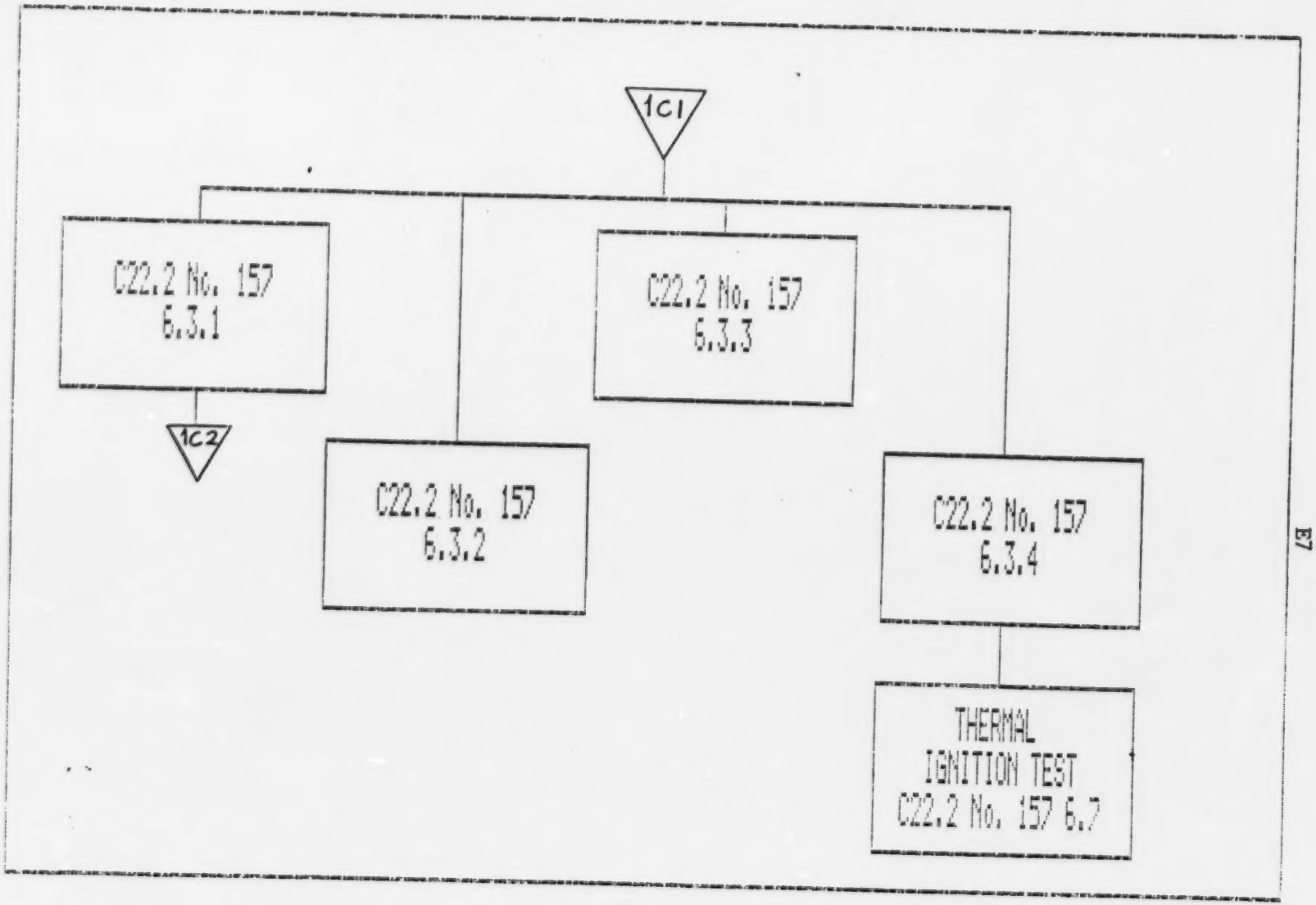
SPECIAL PURPOSE ENCLOSURES C22.2 No. 94
CEC, PART 1 C22.1
CEC, PART 2 C22.2 No. 0
OUTLET/CONDUIT BOXES FITTINGS C22.2 No. 18
ENCLOSURES FOR CLASS II, GROUPS E,F,G C22.2 No. 25
HOT DIP GALVANIZING IRREGULAR OBJECTS CSA G164


1C
CLASS 1: DIVISION 2
C22.2 No. 157
4.2.4
CSA C22.2 No. 157
4.2.4 (a)
CSA C.22.2 No. 157
4.2.4 (b)
NON-INCENDIVE
COMPONENT TEST
C22.2 No. 157 6.6
SEALED COMPONENT
TEST
C22.2 No. 157 6.9
C22.2 No. 157
6.3
C22.2 No. 157
5.1
C22.2 No. 157
5.3
1C1
ADHESIVE TEST
C22.2 No. 157
6.12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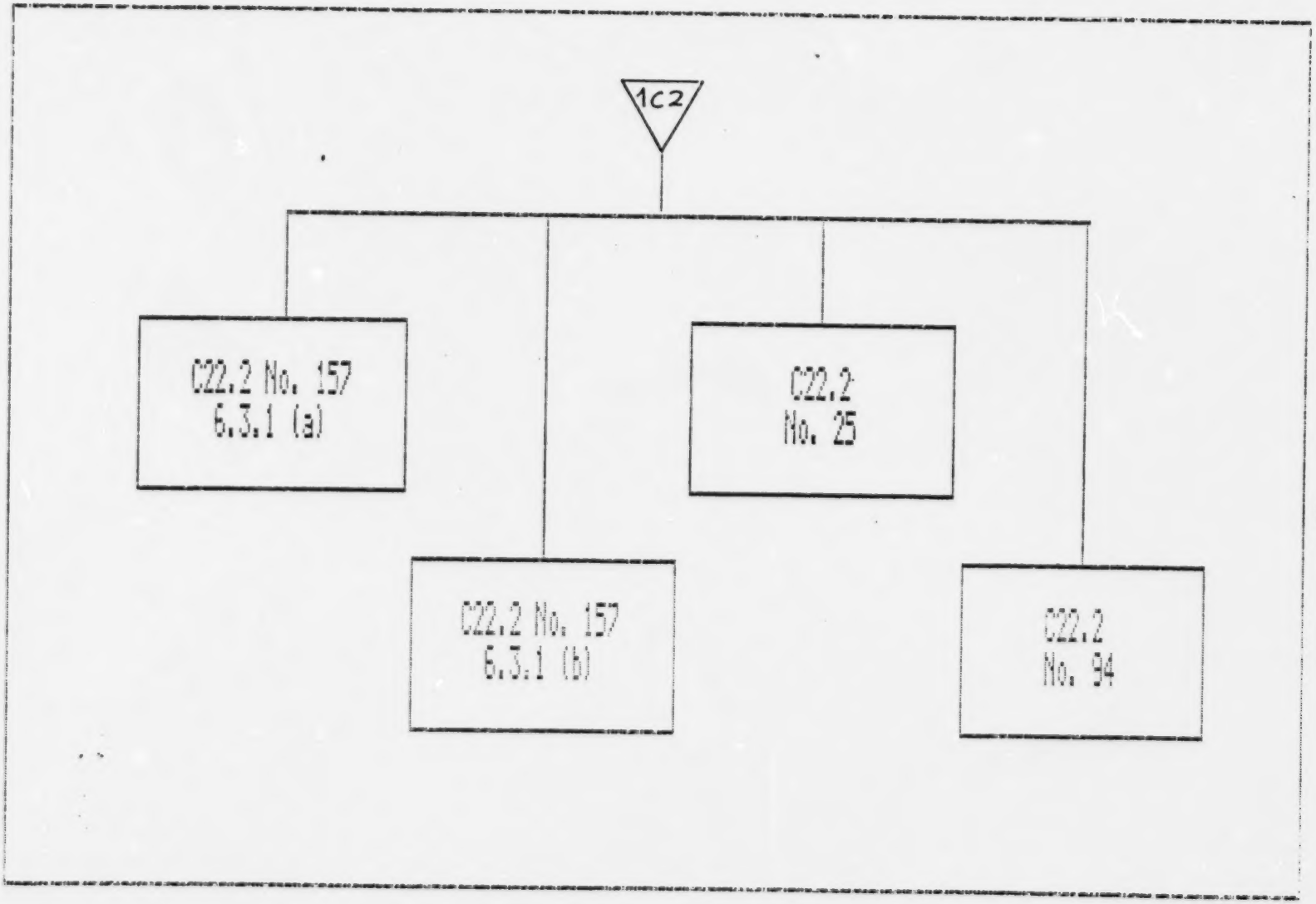
C22.2 No. 157
6.3.1
1C2
C22.2 No. 157
6.3.2
C22.2 No. 157
6.3.3
C22.2 No. 157
6.3.4
THERMAL
IGNITION TEST
C22.2 No. 157 6.7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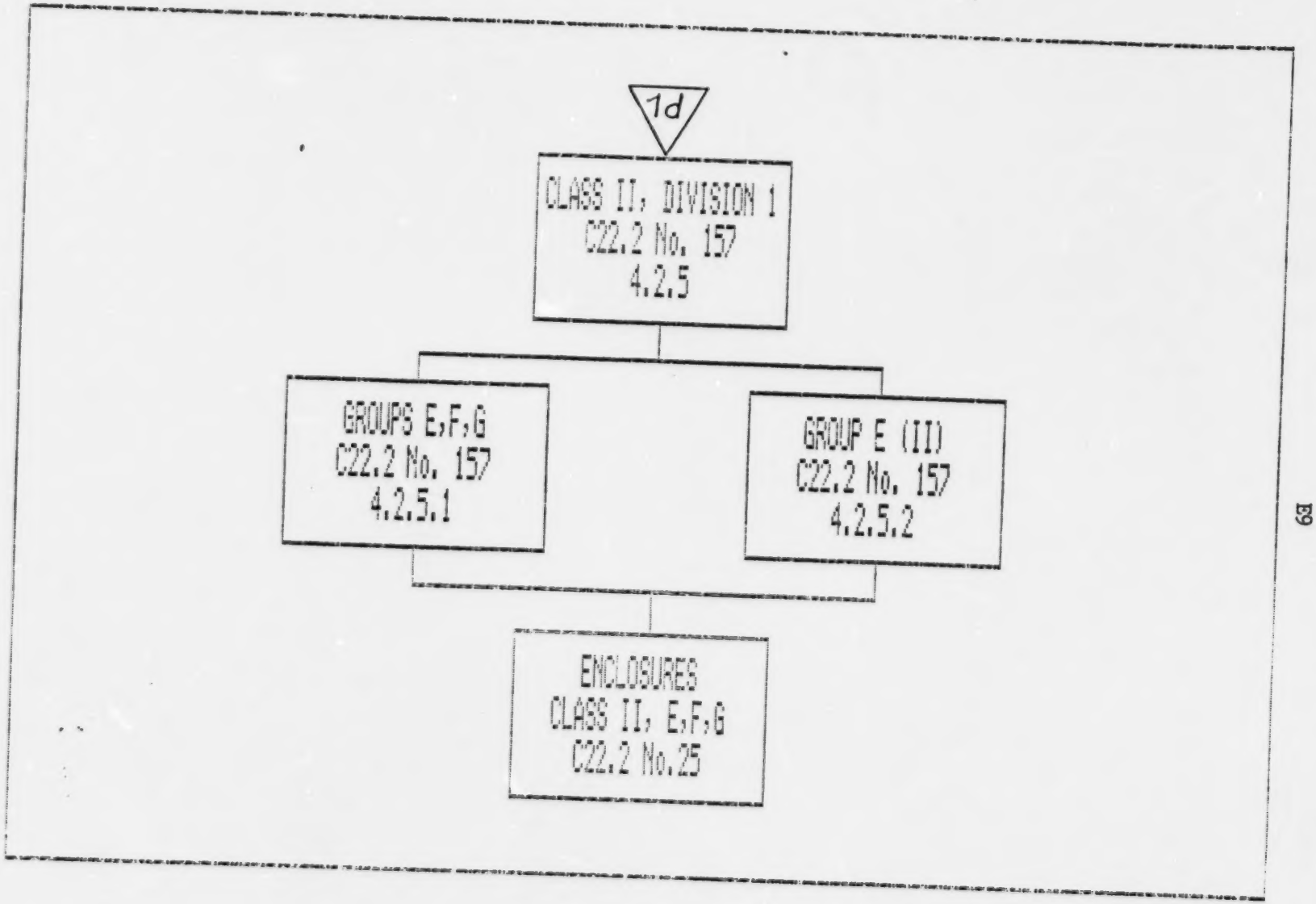
C22.2
No. 25
C22.2 No. 157
6.3.1 (b)
C22.2
No. 94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CLASS II, DIVISION 1
C22.2 No. 157
4.2.5
GROUPS E,F,G
C22.2 No. 157
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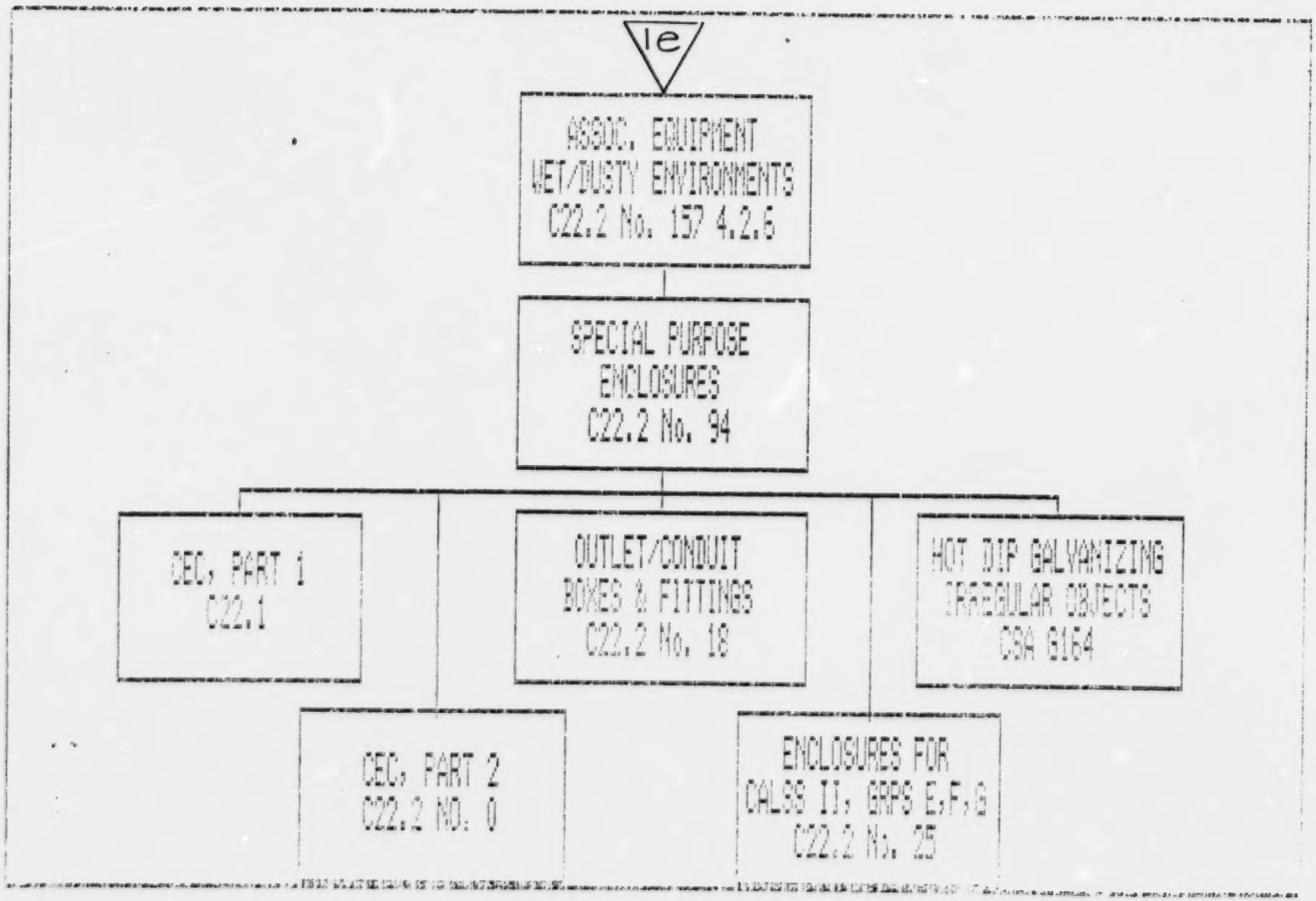
GROUP E (II)
C22.2 No. 157
4.2.5.2
ENCLOSURES
CLASS II, E,F,G
C22.2 No.25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ASSOC. EQUIPMENT
WET/DUSTY ENVIRONMENTS
C22.2 No. 157 4.2.6
SPECIAL PURPOSE
ENCLOSURES
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CEC, PART 1
C22.1
OUTLET/CONDUIT
BOXES & FITTINGS
C22.2 No. 18
HOT DIP GALVANIZING
IRREGULAR OBJECTS
CSA G164
CEC, PART 2
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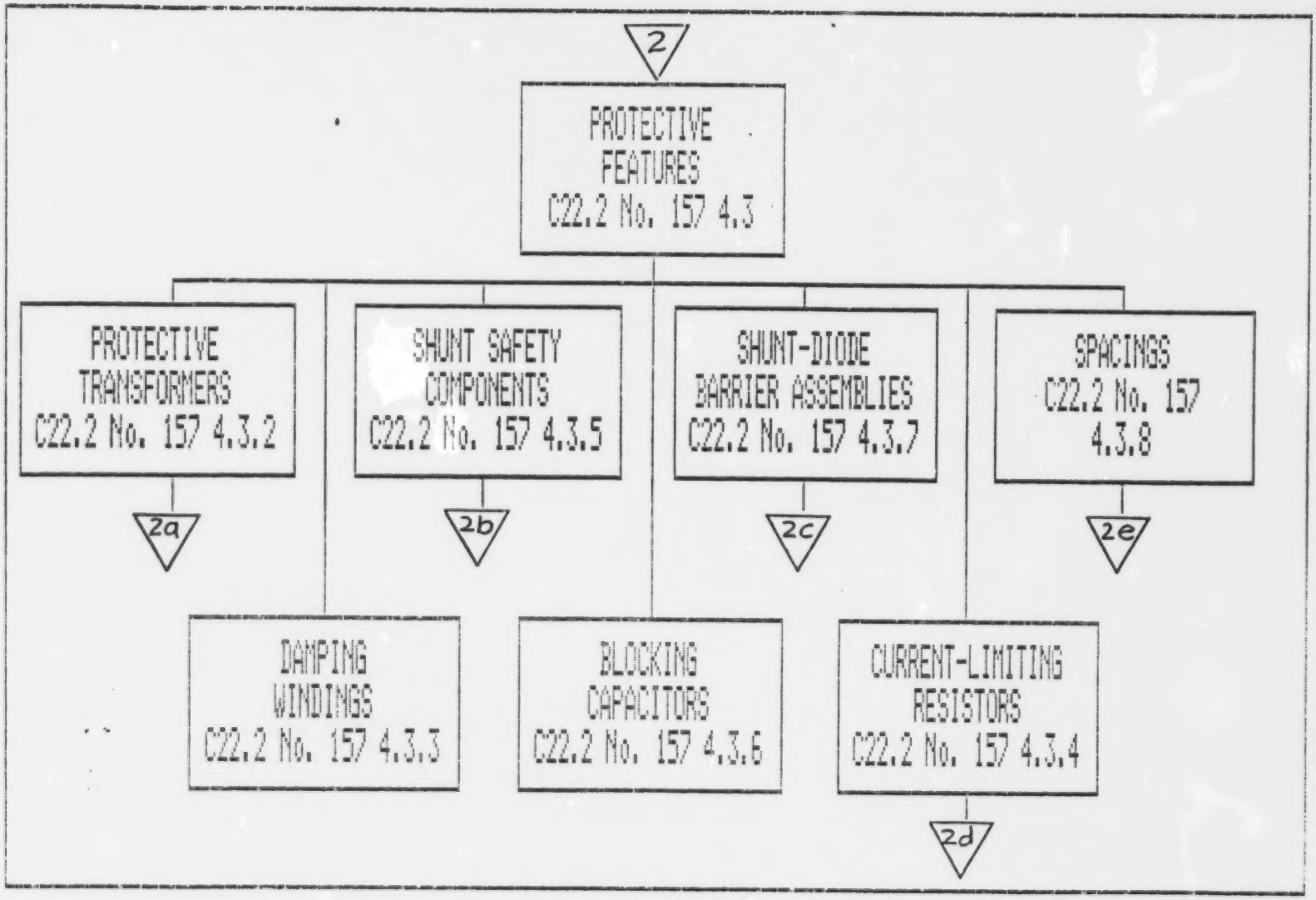
CALSS II, GRPS E,F,G
C22.2 N. 25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PROTECTIVE FEATURES C22.2 No. 157 4.3
PROTECTIVE TRANSFORMERS C22.2 No. 157 4.3.2
SHUNT SAFETY COMPONENTS C22.2 No. 157 4.3.5
SHUNT-DIODE BARRIER ASSEMBLIES C22.2 No. 157 4.3.7
SPACINGS C22.2 No. 157 4.3.8
2a
2b
2c
2e
DAMPING WINDINGS C22.2 No. 157 4.3.3
BLOCKING CAPACITORS C22.2 No. 157 4.3.6
CURRENT-LIMITING RESISTORS C22.2 No. 157 4.3.4
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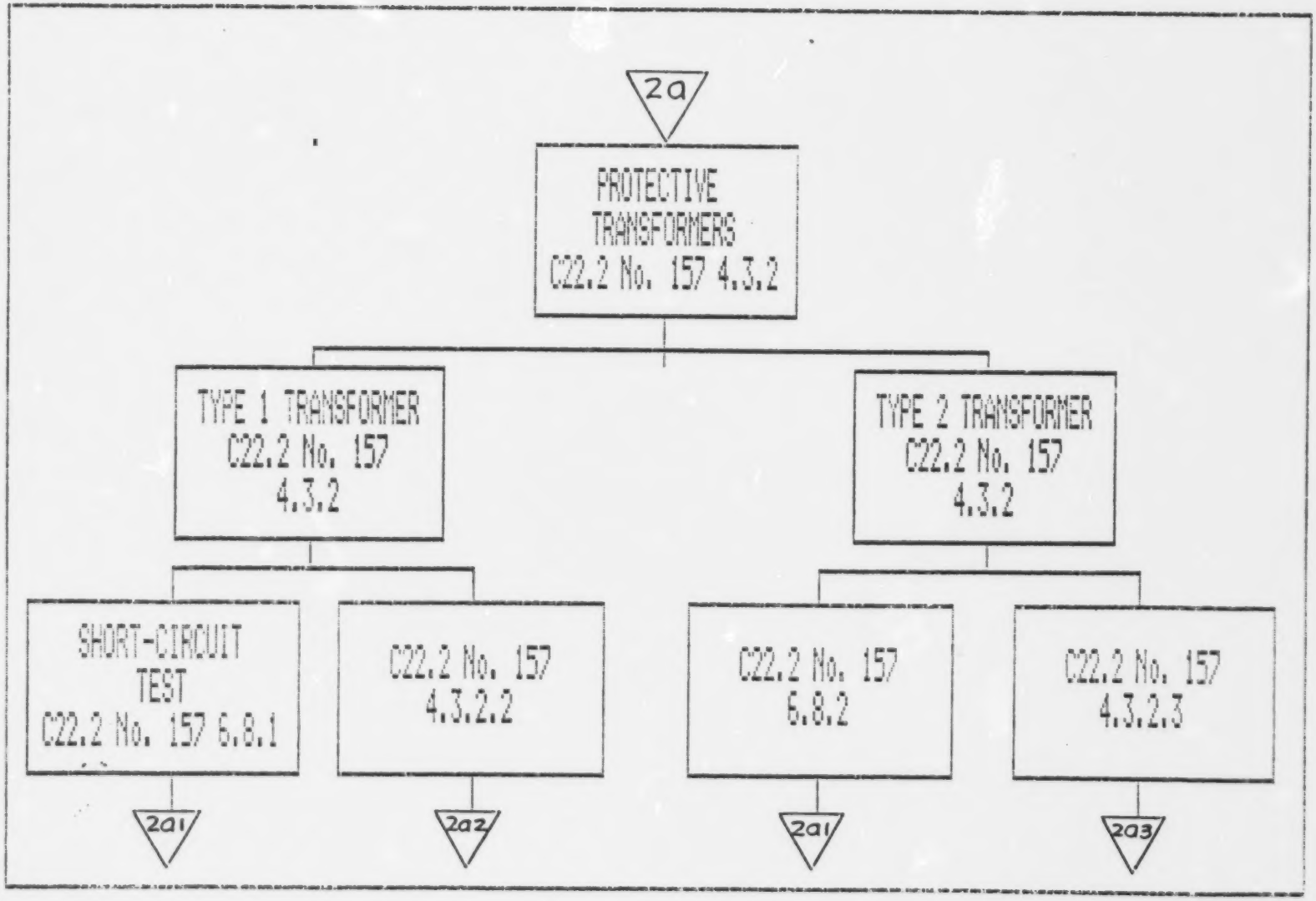
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PROTECTIVE TRANSFORMERS C22.2 No. 157 4.3.2
TYPE 1 TRANSFORMER C22.2 No. 157 4.3.2
TYPE 2 TRANSFORMER C22.2 No. 157 4.3.2
SHORT-CIRCUIT TEST C22.2 No. 157 6.8.1
C22.2 No. 157 4.3.2.2
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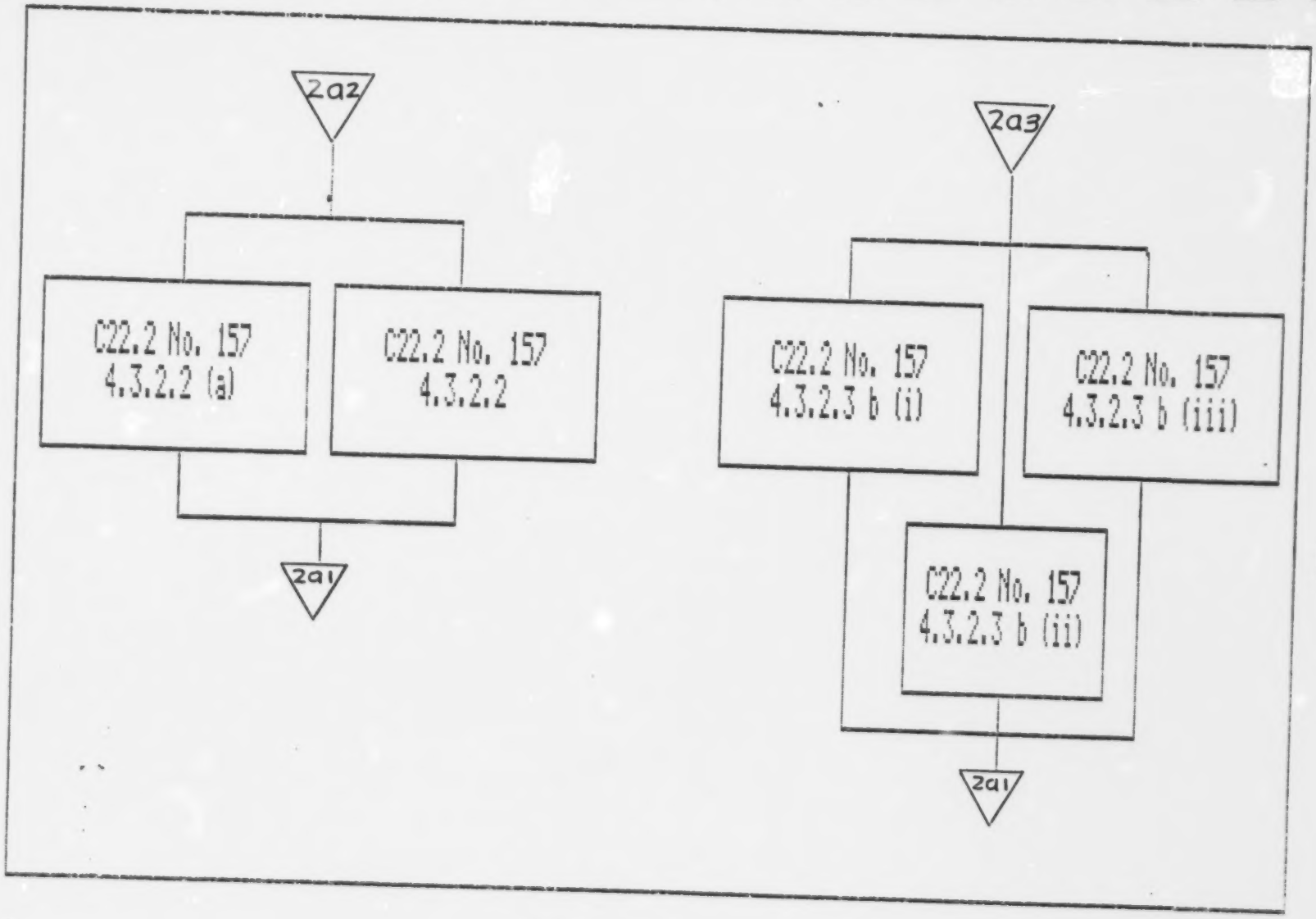
C22.2 No. 157 4.3.2.3
2a1
2a2
2a1
2a3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2a3
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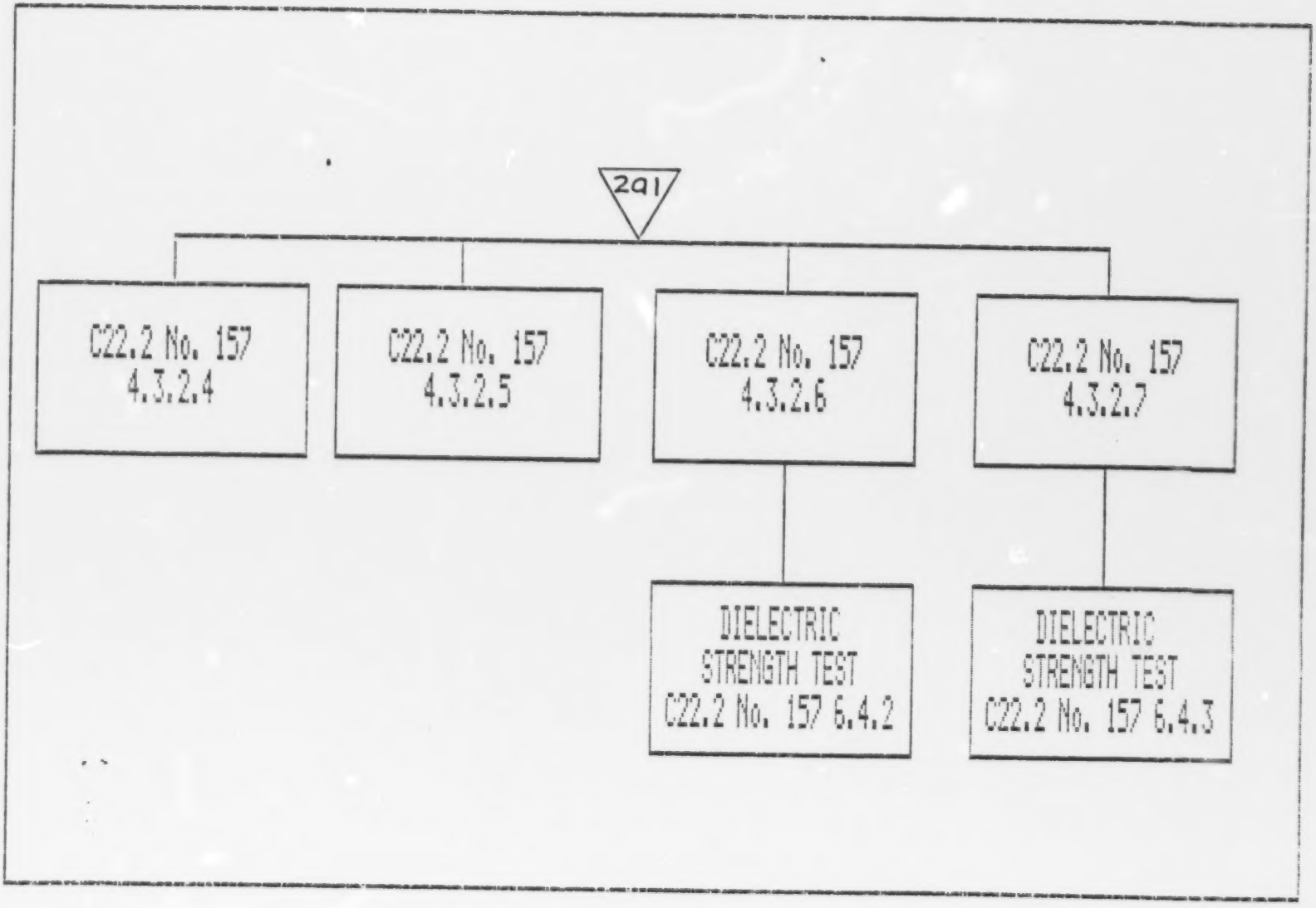
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4.3.2.7
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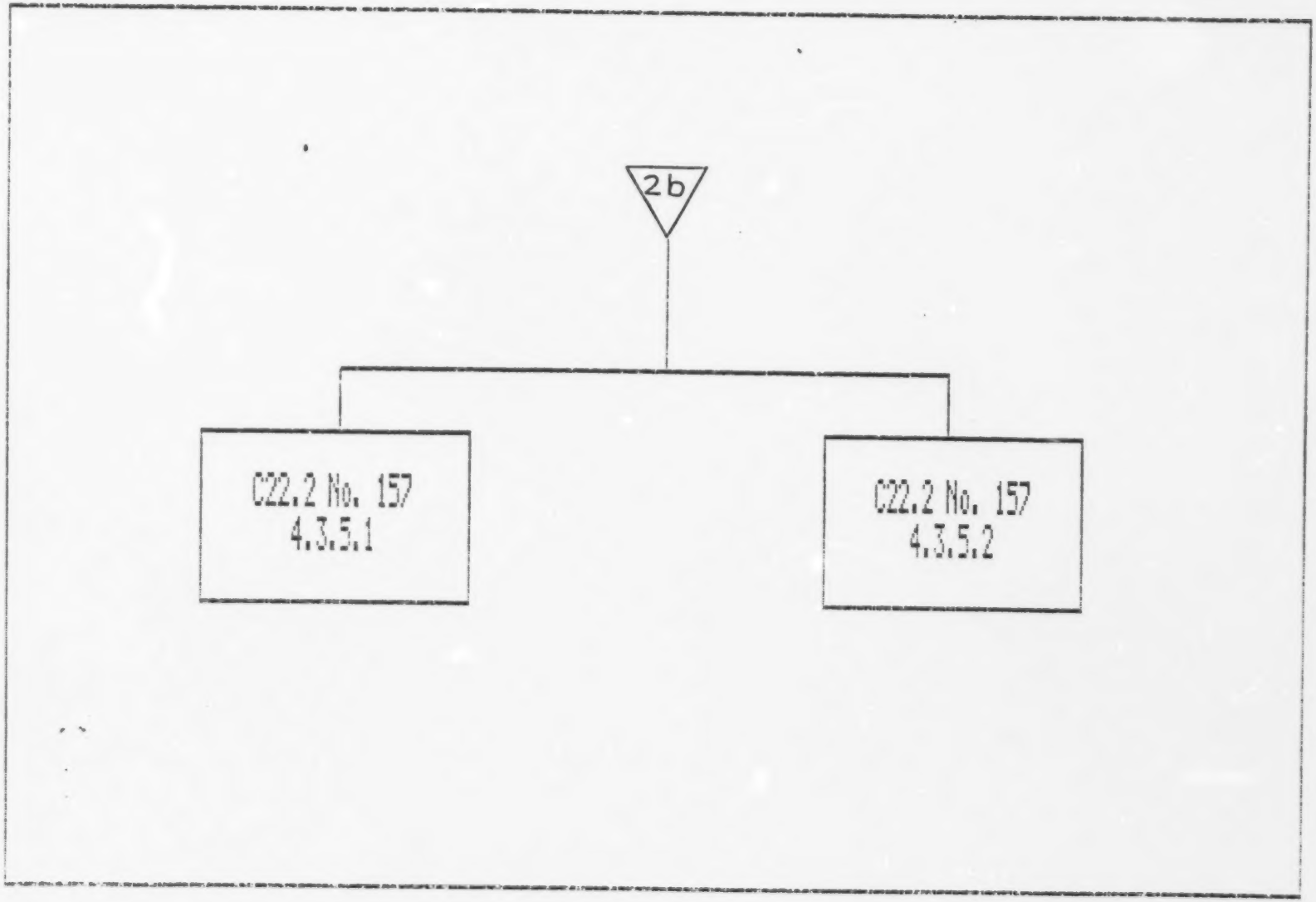
STRENGTH TEST
C22.2 No. 157 6.4.2
DIELECTRIC
STRENGTH TEST
C22.2 No. 157 6.4.3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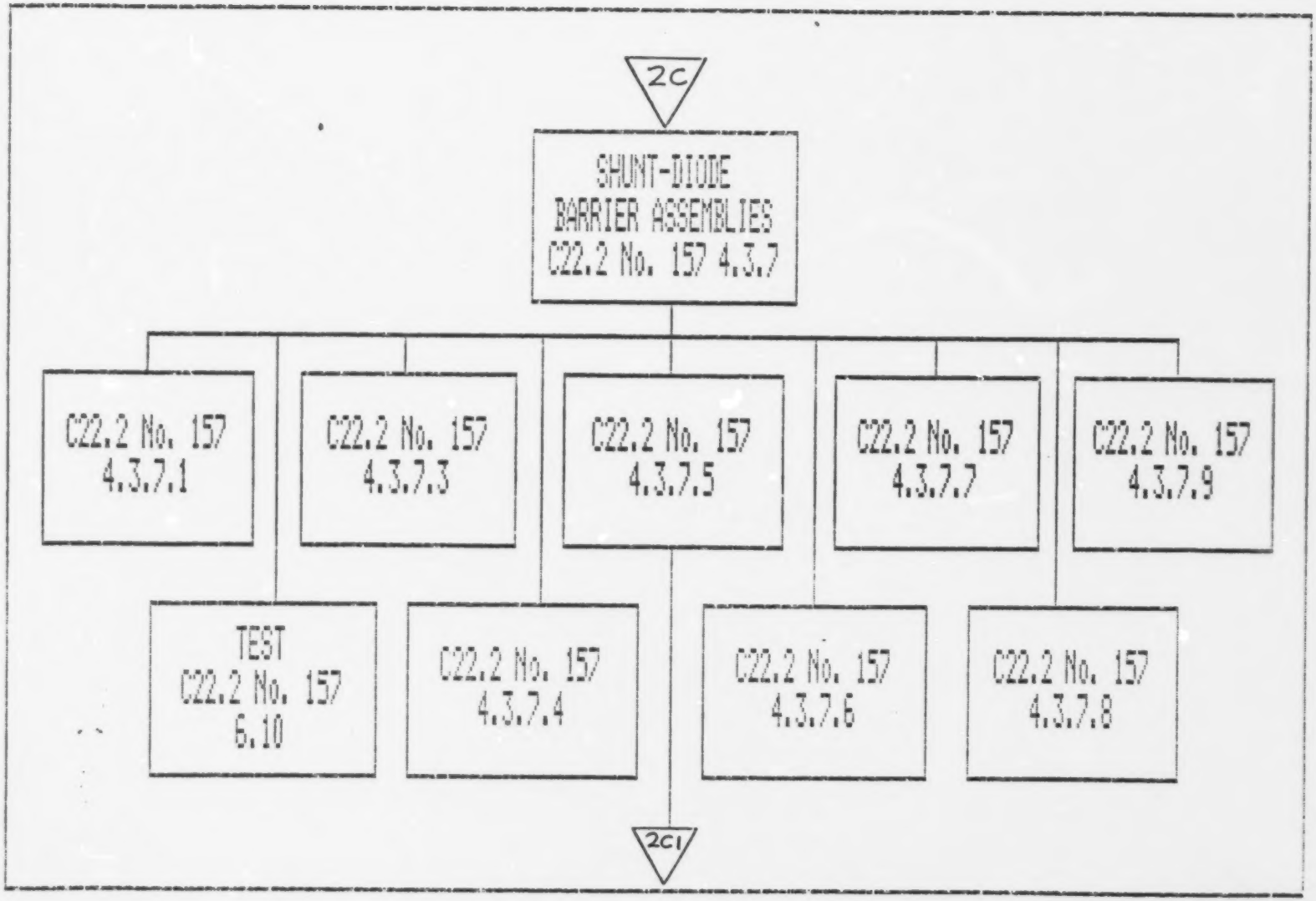
4.3.5.2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BARRIER ASSEMBLIES
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C22.2 No. 157
4.3.7.3
C22.2 No. 157
4.3.7.5
C22.2 No. 157
4.3.7.7
C22.2 No. 157
4.3.7.9
TEST
C22.2 No. 157
6.10
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C22.2 No. 157
4.3.7.8
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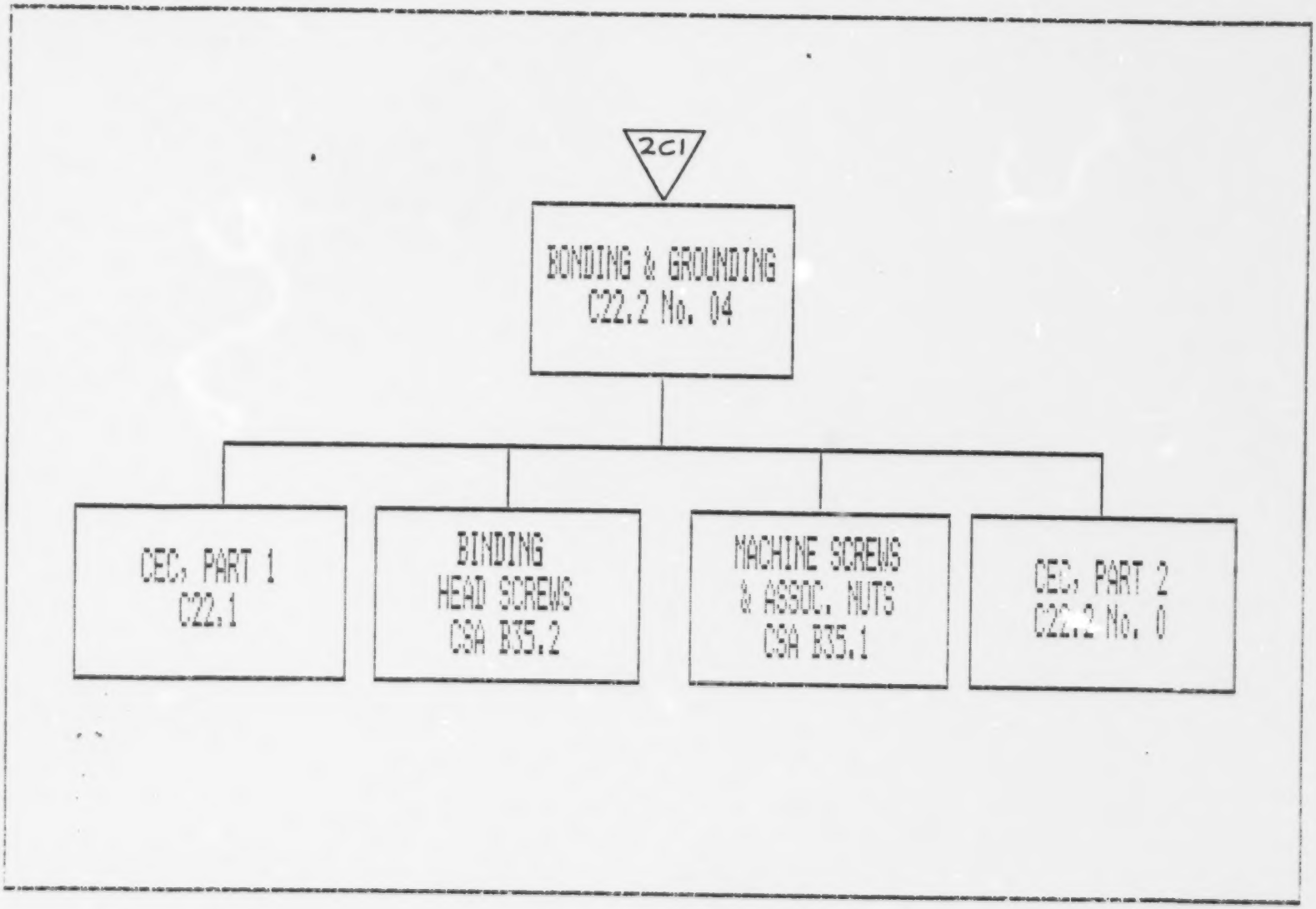
2C1
BONDING & GROUNDING
C22.2 No. 04
CEC, PART 1
C22.1
BINDING
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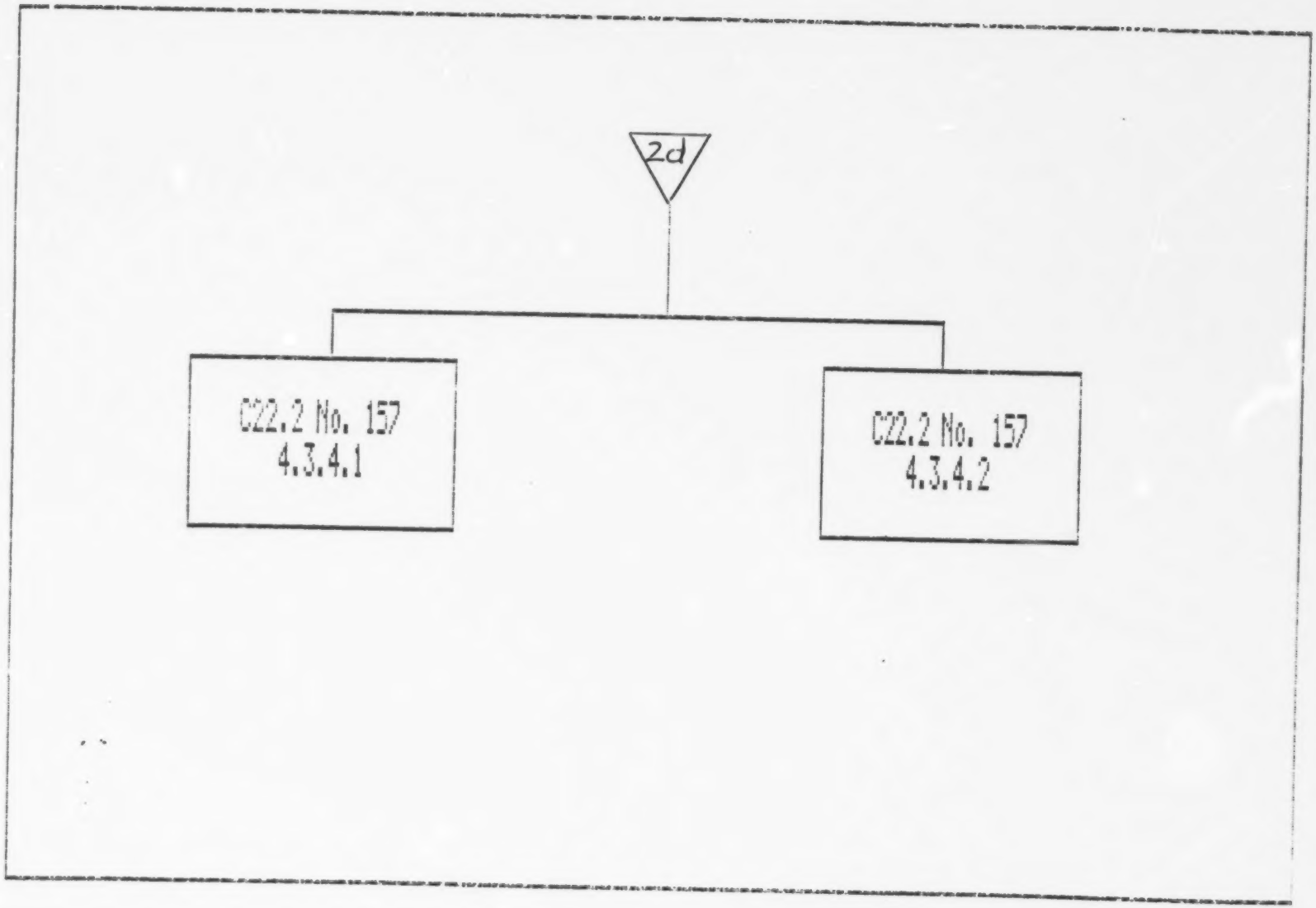
CSA B35.2
MACHINE SCREWS
& ASSOC. NUTS
CSA B35.1
CEC, PART 2
C22.2 No. 0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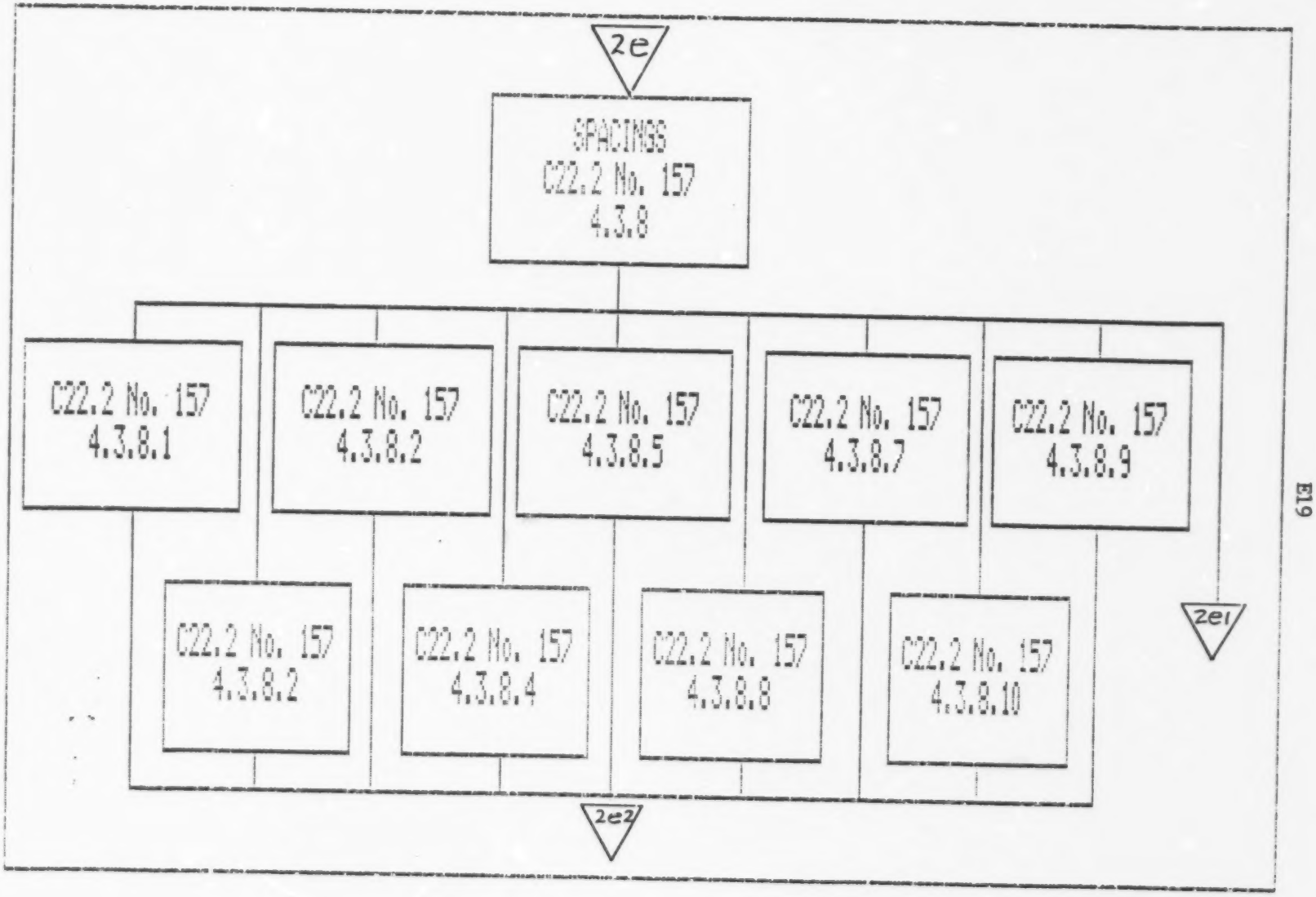
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SPACINGS
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C22.2 No. 157
4.3.8.5
C22.2 No. 157
4.3.8.7
C22.2 No. 157
4.3.8.9
C22.2 No. 157
4.3.8.2
C22.2 No. 157
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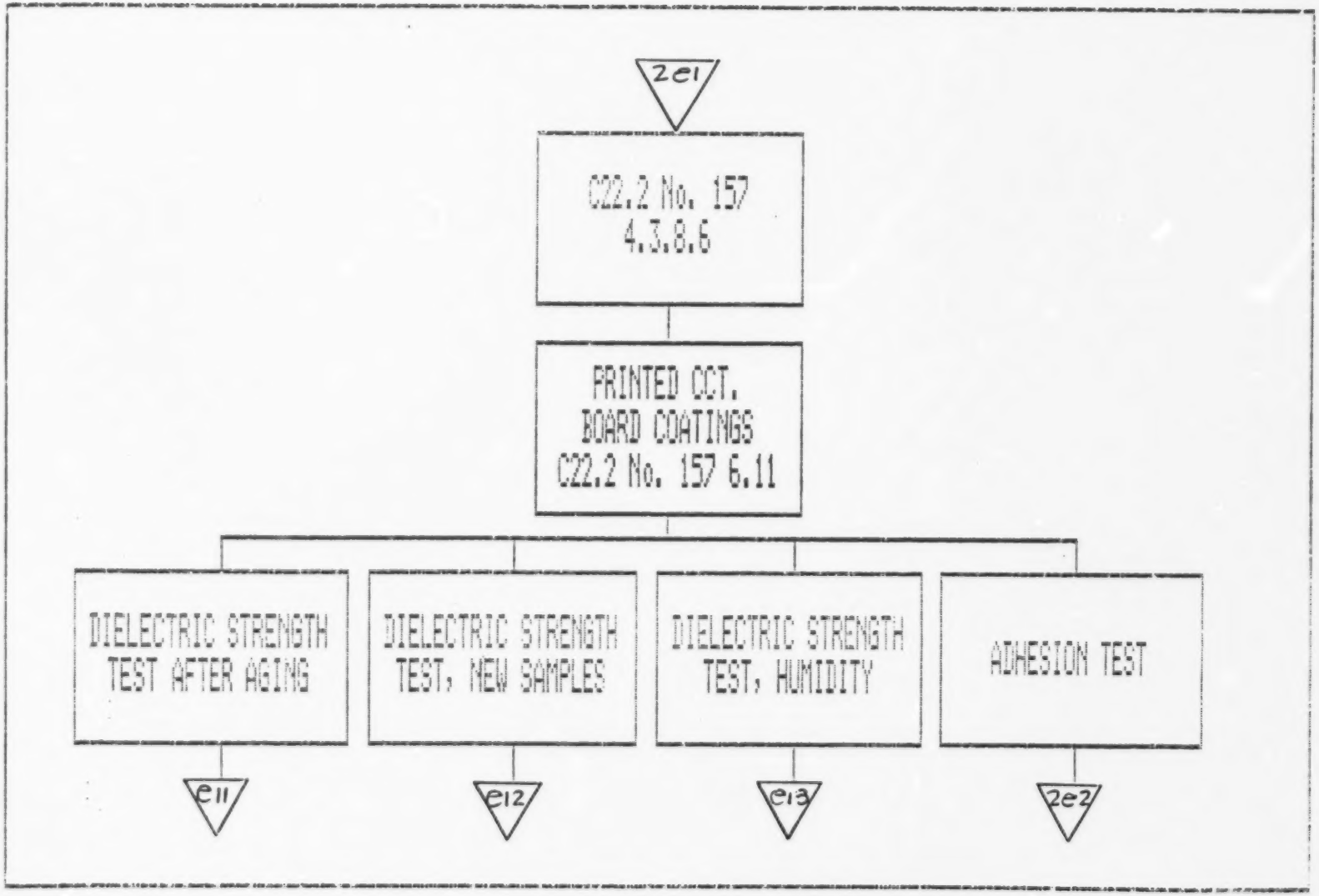
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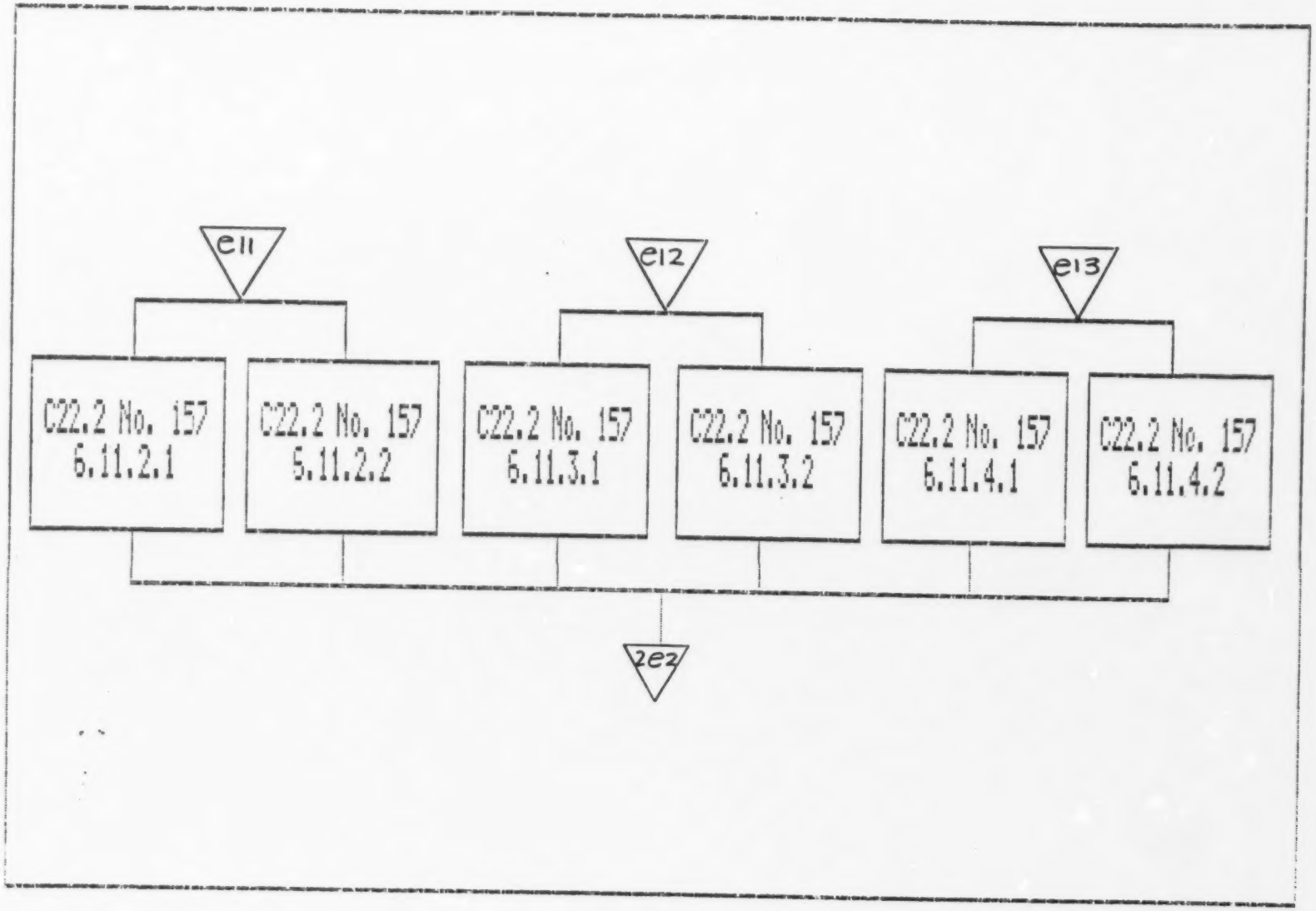
C22.2 No. 157
4.3.8.6
PRINTED CCT.
BOARD COATINGS
C22.2 No. 157 6.11
DIELECTRIC STRENGTH
TEST AFTER AGING
DIELECTRIC STRENGTH
TEST, NEW SAMPLES
DIELECTRIC STRENGTH
TEST, HUMIDITY
ADHESION TEST
e11
e12
e13
2e2


e11
e12
e13
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C22.2 No. 157
6.11.3.1
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2e2

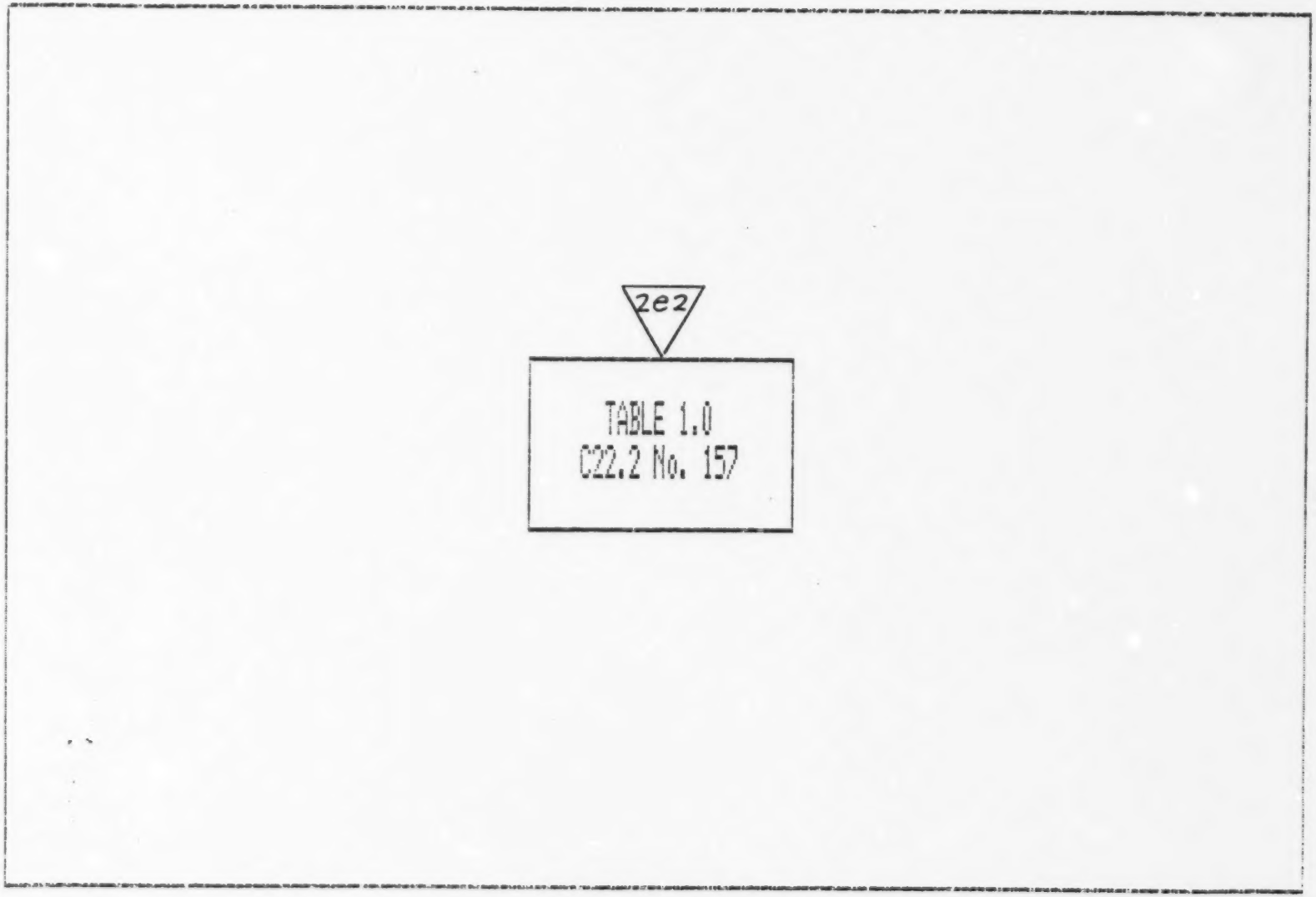
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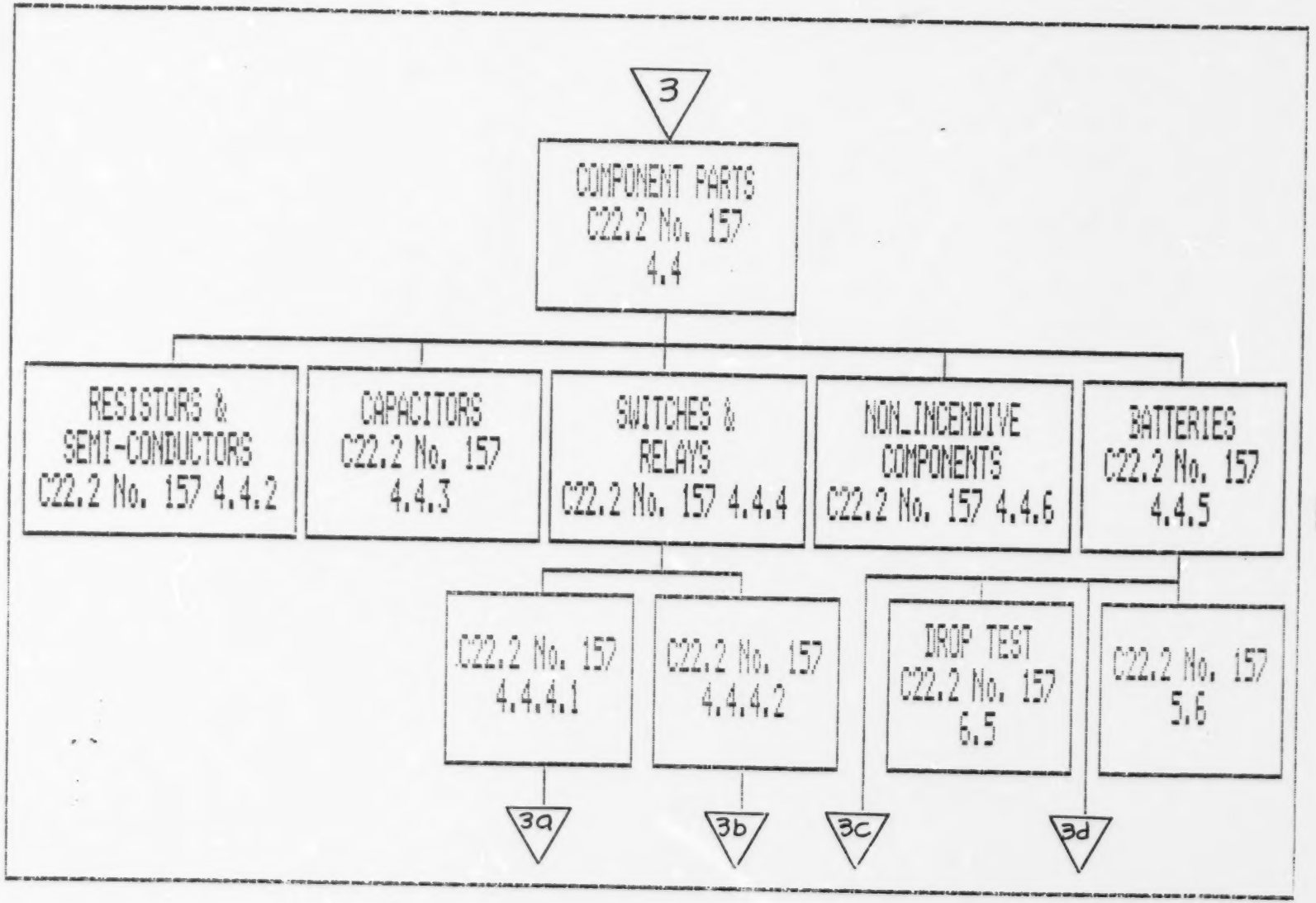
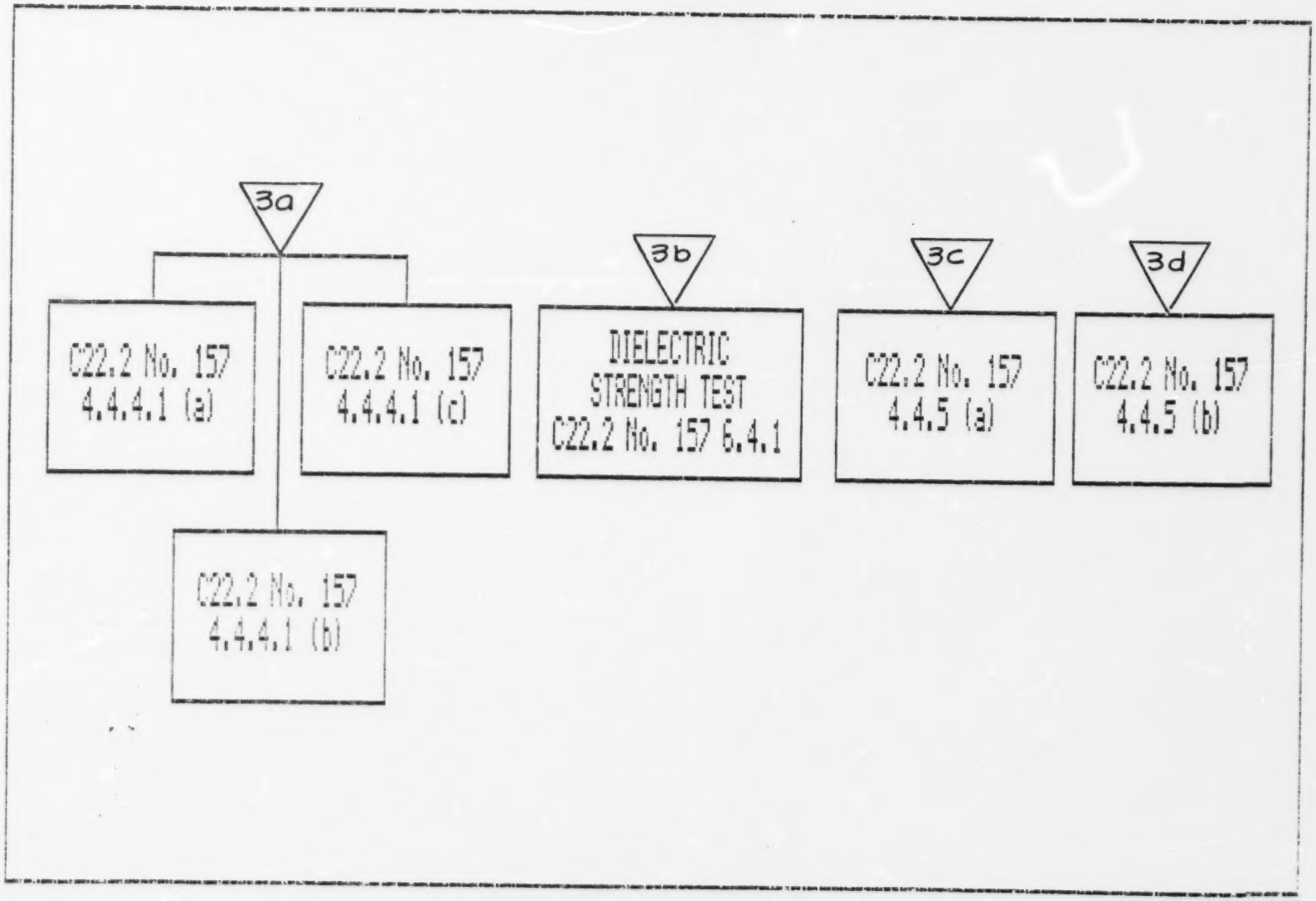
TABLE 1.0
C22.2 No. 157


3
COMPONENT PARTS
C22.2 No. 157
4.4
RESISTORS &
SEMI-CONDUCTORS
C22.2 No. 157 4.4.2
CAPACITORS
C22.2 No. 157
4.4.3
SWITCHES &
RELAYS
C22.2 No. 157 4.4.4
NON-INCENDIVE
COMPONENTS
C22.2 No. 157 4.4.6
BATTERIES
C22.2 No. 157
4.4.5
C22.2 No. 157
4.4.4.1
C22.2 No. 157
4.4.4.2
DROP TEST
C22.2 No. 157
6.5
C22.2 No. 157
5.6
3a
3b
3c
3d


3a
3b
3c
3d
C22.2 No. 157
4.4.4.1 (a)
C22.2 No. 157
4.4.4.1 (c)
DIELECTRIC
STRENGTH TEST
C22.2 No. 157 6.4.1
C22.2 No. 157
4.4.5 (a)
C22.2 No. 157
4.4.5 (b)
C22.2 No. 157
4.4.4.1 (b)

APPENDIX F

NFPA No. 496-1974
"Purged and Pressurized Enclosures
for Electrical Equipment in Hazardous Locations"

NFPA No. 496-1974

Part A: Purged Enclosures for Electrical Equipment in Class I Hazardous Locations.

Chapt. 2: Enclosures with a gross internal volume not exceeding 10 cubic feet.

General Requirements:

1. Non-combustible material not likely to be broken.

2. Windows of tempered glass 1/4" thick, or shatter-proof glass/material.

3. If hazardous vapours/gases have collected within enclosure through opening or failure of purge, the enclosure must be purged.

4. Once the enclosure has been purged of hazardous gases, positive pressure shall be maintained within the enclosure.

5. Compartments within the main enclosure or adjacent enclosures connected to the main enclosure shall be considered separately and protection provided by one of the following three methods:

    (1) Compartments shall be vented to the main enclosure by top and bottom vents, having a minimum size for each vent of one square inch per 400 cubic inches of the volume of the internal or adjacent enclosures.

    (2) The compartment shall be separately purged, or

    (3) the equipment in the compartment shall be protected by other means.

6. To exclude the entrance of hazardous gases in the event that the enclosure is opened or the purge fails, suitable devices such as indicators, interlocks shall be provided.

7. The purging supply shall be essentially free of dust and liquids. It shall contain no more than trace amounts of flammable gases/vapours.

8. Air of normal instrument quality shall be acceptable as the purging supply as well as inert gases.

9. The compressor suction line shall be designed to prevent leaks into the compressor.

10. If air is used, the compressor intake shall be located in a non-hazardous area.

11. If the compressor suction line is in a hazardous area, it shall be constructed of non-combustible material, designed to prevent leaks of hazardous vapour into the system, and protected against mechanical damage and corrosion.

12. When double purging is used, the two sources of air shall be independent and automatic shutdown shall be provided.

Type X Purging: Reduces the classification within an enclosure from Division 1 to non-hazardous.

Specific Requirements:

1. A timing device shall be incorporated to prevent power from being applied until after an elapse of time sufficient to permit at least four enclosure volumes of purge gas (ten for motors) to have passed through the enclosure while maintaining an internal pressure of at least 0.1" of water.

2. The timing device shall be suitable for use in the location in which it is installed.

3. The manufacturer shall recommend purge conditions and flow rate necessary to pass four enclosure volumes in a stated time.

4. The enclosure shall be maintained under a positive pressure of not less than 0.1" of water when the power is on.

5. A Shut-Down System and Backup shall be incorporated to remove potential automatically from all circuits within the enclosure not suitable for Division 1 upon failure of the purging supply.

6. A door switch shall be provided to remove potential automatically from all circuits within the enclosure not suitable for Division 1 upon failure of the purging supply, if the enclosure can be readily opened without the use of a key or tools.

7. The door switch, although located within the enclosures, shall be suitable for Division 1 locations.

8. The maximum operating temperature of any surface exposed to the atmosphere within the enclosure shall not exceed 80% of the ignition temperature (oC) of the gases/vapours involved, as determined by ASTM D2155-66.

Exceptions:

(1) Temperature limits may be exceeded if qualified testing has determined that the hot components will not ignite the specific gases/vapours involved.

(2) Temperature limits may be exceeded if the surface having this temperature is enclosed within a chamber hermetically-sealed against the entrance of gases/vapours.

9. Equipment such as motors, transformers and other equipment which may be overloaded shall be provided with appropriate devices to detect any increase in temperature beyond design limits and to de-energize the equipment automatically.

10. The power cutoff switch provided to remove power upon failure of the purging system, shall be either flow or pressure actuated.

11. The power cutoff switch shall be suitable for use in the location in which it is installed.

12. To avoid plugging when a pneumatic device is used, any restrictions between the device and the enclosure shall have passages no smaller than the smallest passage before the device.

13. If a pneumatic device is used, no valve between the device and the enclosure shall be permitted

14. The pressure or flow device (i.e. power cutoff switch) shall be capable of cutting off power when the purging pressure or flow is inadequate to maintain a static pressure within the enclosure of at least 0.1" of water.

15. The pressure device shall be capable of cutting off power if pressure exceeds or falls below a pre-determined safe range.

16. A warning nameplate shall be mounted on the instrument in a prominent location and be visible before the enclosure is opened.

17. The manufacturer shall recommend purge conditions and flow rate necessary to pass at least four enclosures' volumes in the slated time, X.

18. An alarm or indication of pressurized system failure shall be provided. The signal may be audible or visual.

Exception:

If immediate interruption of power would result in a condition more hazardous than that created by failure to remove the power audible as well as visible alarms suitable for the area, must be energized.

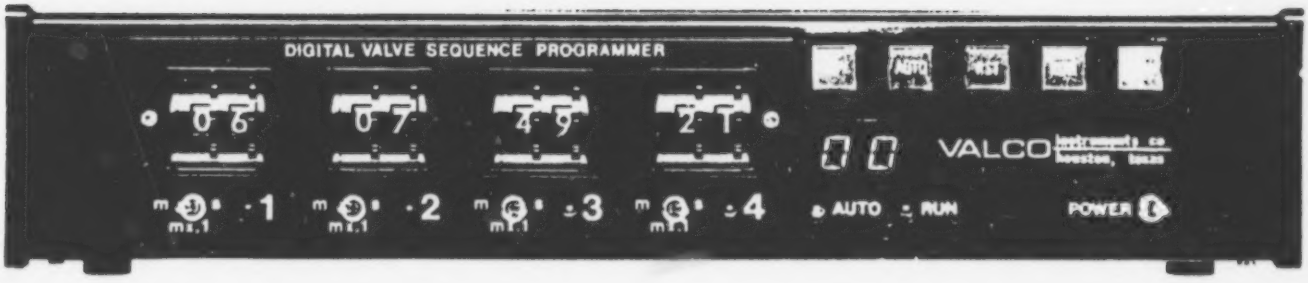
APPENDIX G

Product Information from
VALCO, SENTEX and RAPCO

VICI

Valco Instruments Co. Inc.

Digital Valve Sequence Programmer



Features

- Two-digit thumbwheel switches for setting desired timed period in each interval. (±60 microsec repeatability in all models.)
- Indicator lights show interval being timed.
- Mode switches for selecting among minutes, tenths of minutes or seconds in each interval.
- Two second pulse output at interval change.
- Two double throw isolated contacts on each interval for output functions.
- Digital Elapsed Time Readout.
- Crystal time base for freedom from power line frequency variations (±.0025% accuracy).
- CMOS logic for highest noise immunity.
- No moving parts other than output relays.

Description

The Valco Digital Valve Sequence Programmer, (DVSP) is a sequential timer/programmer with 2, 3 or 4 intervals. Each interval has a pair of digital time switches, a three position toggle switch, an LED and an output relay. The LED indicates the position of the DVSP and the output relay is energized whenever the program is on or off. The pair of digital time switches selects the length of time the programmer will spend in that interval before advancing to the next one. The three position toggle switch determines whether the time set on the digital is to be minutes, tenths of minutes or seconds.

When the timer is not running (RUN LED off), the DVSP will stay in an interval indefinitely unless the digital time switches are set to "00". The DVSP will not stay in any interval with "00" on the digital switches under any circumstances.

A two digit elapsed time display operates when the timer is running. The display follows the setting of the three position toggle switch and indicates how many minutes, tenths of minutes or seconds have passed since the timer began running in its current interval. If the toggle switch is set for tenths of minutes, the decimal point between the two digits is lighted. When the timer is counting minutes, the decimal point flashes at a 1 Hz rate and may be used by the operator to count seconds.

Typical Applications

- Energizing of external solenoid valve.
- Contact closure during interval.
- Polarity reversal of signal.
- Control of integrator and switching of valves.

Controls

Power Switch
Toggle switch marked POWER turns DVSP off and on. The elapsed time display serves as the power light.

RST (Reset)
Stops the timer, puts the DVSP in the standby position (no interval addressed and no relays energized) and in "single cycle" mode.

Run
Starts the timer and, if the DVSP is in the standby position, moves it out to the first interval not set to "00". Lights the RUN LED.

Stop
Stops the timer and resets it to zero, but causes no change of interval, and has no effect on output relay. RUN LED goes off.

Auto
Determines what happens after last interval. In AUTO mode (AUTO LED lighted) the DVSP will return to interval 1 (or first non-zero interval) and repeat sequence. In single cycle mode (AUTO LED off) the DVSP will enter the standby position. Pressing the AUTO push-button puts the DVSP in the AUTO mode and pressing it again returns it to the single cycle mode.

ADV
Advances the DVSP into the next (non-zero) interval. All functions, outputs, etc. occur exactly as if the timer had reached its setting and advanced into the next interval on its own.

Specifications

General
3 wire cord (2 meters)
Externally accessible 2A fuse
115/230 VAC, 195-250 VAC, 25-60 Hz operation 2, 3 or 4 intervals. Each interval settable 00-99 seconds, 0.0-9.9 minutes or 00-99 minutes from front panel.
SPDT relay contacts rated 3 amps @ 120 VAC resistive load on each interval.
Elapsed time display.

Dimensions
30 cm (12.35 in.) W × 15 cm (6 in.) D × 6 cm (2.4 in.) H. Weight 2 Kgm (4 lbs.)

Accuracy
The DVSP uses as a time base a 2.097152 Mhz (2^{21} Hz) quartz crystal with a guaranteed accuracy of .0025%. This is 2 seconds per day maximum error. Advancing from one interval to the next is accomplished in 7.6 microseconds, which would cause an accumulated error of one (1) second after 131,072 interval changes.

Temperature Range
0-70°C

Power Consumption
115 VAC @ 50 mA

Ordering Information

Order The Part Number DVSP 3

Digital Valve Sequence Programmer
Number of Intervals Designator

Many special features can be added to the standard DVSP that are routine for VALCO. For example: remote sampling points selected by a VALCO MULTIPOSITION valve can be bypassed, contact closures can be counted up to a set-point and valve position readout can be displayed for stream or sample identification. We invite your inquiries at VALCO. No application is too unusual to discuss.

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Telex 79-0033

VICI AG **Valco Europe**
Tannberg P.O. Box 13 CH-6214 Schenkon
(045) 216868
Telex 868342 vici ch

Rev. 11/85

VICI

Valco Instruments Co. Inc.

High Frequency Linear Response Electron Capture Detector

Valco Model 140B*

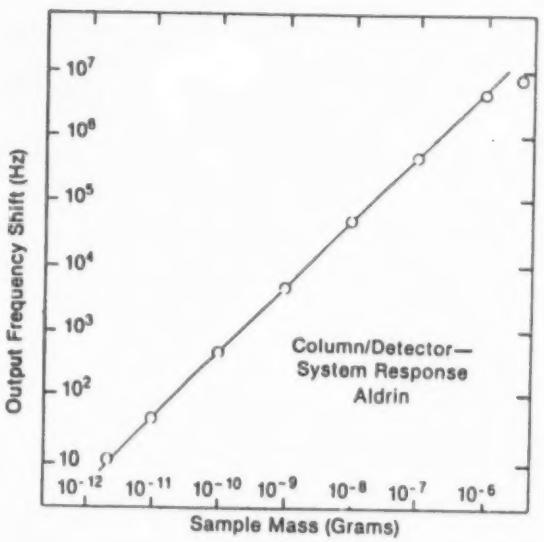
* U.S. Patent No. RE. 28,951

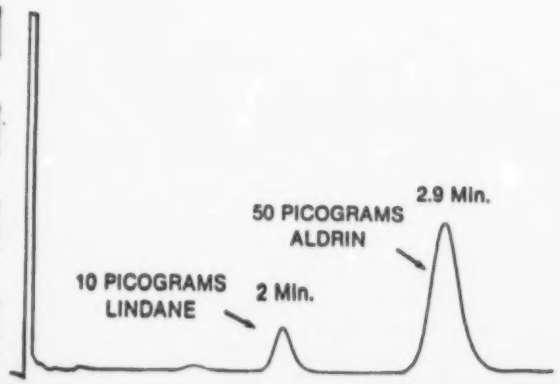
The model 140B provides you with the best available pesticide, solvent and gas analysis with no base line drifts, sensitivity changes or linear dynamic range limitations.

The Valco Model 140B Wide Range Electron Capture Detector (WRECD) system is comprised of a Detector Assembly and a Control Unit. The Detector Assembly normally mounts on the outside of the column oven with its input tubing extending into the oven to receive the effluent from a GC column. A make-up gas connection is supplied for low column flow applications. The Control Unit, which contains all the electronics and controls associated with the detector, may be located remotely (i.e., up to 5 feet) from the detector. The system is self-contained, requiring no external power supply or signal-processing amplifier. The Model 140B provides both an analog signal suitable for driving a linear chart recorder and a variable-frequency pulsed output suitable for driving standard digital counters.

The Model 140B can free you from the baseline drifts, sensitivity changes, and linear dynamic range limitations of other ECD designs. This proven system extends the linear dynamic range to five or six decades of sample concentration. Used with a suitable GC column, this detector permits quantitative analysis from picograms to micrograms with no need for expensive reruns or critical sample sizing.

Best of all, the Model 140B detector system was designed to be easily attached to the column of your GC, upgrading its performance to equal or surpass that of any brand new instrument. The Model 140B is a stand-alone detector, complete with power supply and precision detector temperature control. Its analog recorder output will drive your chart recorder directly, and its pulsed output is compatible with standard commercial wide-ranged frequency monitors.





OUTPUT FROM VALCO'S WIDE-RANGE ECD SYSTEM IN A TYPICAL GC APPLICATION

A Direct Solution to the linearity problem

Using short charge-collecting voltage pulses, which enhance baseline stability, the detector system applies the pulses at whatever rate is required to maintain a constant integrated anode current. In this configuration, the differential pulse rate, Δf, is a linear function of electronegative vapor concentration over a dynamic range approaching six decades for some gases, and the baseline frequency (in the presence of pure carrier gas) is extremely stable. As an example, common chlorinated pesticides can be measured linearly over five decades of dynamic range. Other compounds, such as SF_6, can be measured over a 6-decade range.

ailable as Independent Accessory

Purchasing a Model 140B detector system is a convenient and economical way to upgrade an existing GC system to formance levels far exceeding those of many new in- uments.

asily Connected to Existing s Chromatographs

Inlet exhaust and make-up gas tubings are provided on the detector block assembly for convenient connection to ex- ng columns. The Control unit is designed for simplicity in eration and versatility in control.

equires No Source License

e detector uses tritiated scandium foil, which operates up to 320°C. Unlike Nickel-63-source detectors, VALCO's scandium-source detectors are approved for distribution to yone and require no specific radioactive materials license wipe testing.

as History of Reliability

tector and electronic circuits have been in use for more than five years in many hundreds of successful installations.

Directly Compatible with Standard Data Monitors

Pulsed output is provided for continuous wide-frequency-range digital monitoring. Analog output signal (0-10V) derived from internal multirange frequency-to-current converter, drives a linear chart recorder directly — no separate electrometer amplifier required. A 0-1mv analog output attenuator is supplied unless otherwise specified. Other optional analog output ranges may be chosen, either 0-10mv full scale or 0-1V full scale.

Eliminates Need for Time-Consuming Chromatographic Reruns

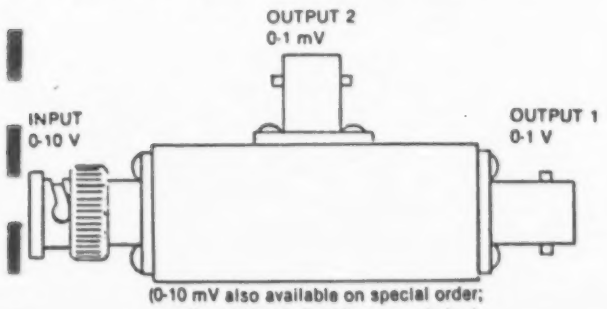
Wide-range gas analysis can be made in a single, uninterrupted run by monitoring the frequency output of the Model-140B system. The need for time-consuming chromatographic reruns resulting from non-optimum sample sizing can now be avoided.

vailable Options

Output Signal Attenuators

odel 140B-3 Dual Output Attenuator

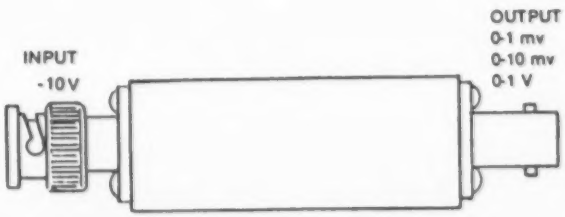
The Model 140B-3 Dual Output Attenuator converts the 0 to 10V analog signal output from J4 of the Control Unit of the LCO Model 140B Wide-Range Electron-Capture Detector system to two simultaneous outputs of 0 to 1V and 0 to 1mV. For example, with the use of the Model 140B-3 Dual Output enuator, a 0 to 1mV strip chart recorder and a data processor which requires an input of 0 to 1V could be used with the VALCO Model-140B Wide-Range Electron-Capture Detector simultaneously. The overall size of the Model 0B-3 attenuator is 4 inch × 1 1/8 inch × 7/8 inch. BNC- e connectors are used on the attenuator.



(0-10 mV also available on special order; specify 140B-3 [0-10 mV] when ordering)

Model 140B-4 Single Output Attenuator

The Model 140B-4 Single Output Attenuator* reduces the 0 to 10V analog signal output from J4 of the Control Unit of the VALCO Model 140B Wide-Range Electron-Capture Detector system to either 1mv, 10mv, or 1V to drive a strip chart recorder or a data processor. The overall size of the Model 140B is 4 inch × 1 1/8 inch × 7/8 inch. When ordering, please specify the output voltage required, if other than 0-1mv full scale.



*One 140B-4 is supplied with each Model 140B Wide-Range Electron-Capture Detector System.

Interface Module

VALCO Model 140B-30 Integrator Interface

e Model 140B-30 Integrator Interface Module is an accessory for use with the VALCO Model-140B Wide-Range Electron-Capture-Detector System. By adding this interface odule to the control unit of the Model-140B system, a 0 to signal suitable for driving a digital integrator becomes available. This signal is independent of the recorder output attenuator on the Model-140B control unit and will not be affected by changes in the attenuator setting.

The Model-140B-30 module fits inside the control unit of the 140B system and obtains its operating power from the control unit. It can be easily installed, using only a screwdriver. Its output BNC connector is easily accessible at the rear panel of the 140B control unit.

Specifications

Overall Specifications

BASELINE CURRENT: Typically over 2×10^{-8} A with scandium-tritide source.
RECORDER OUTPUT: Linear analog voltage, 0-10 volts with customer-selected attenuator for any smaller range to 1mV. Binary stepped attenuator provides output attenuation from 1 to 32768 (2^{15}).
FREQUENCY OUTPUT: From 5×10^3-Hz baseline to 1×10^6-Hz maximum.
BASELINE FREQUENCY STABILITY: ± 5 Hz, short term.
DYNAMIC RANGE: Output Δ f linear with sample concentration from 5 Hz to beyond 5×10^5 Hz for Aldrin, 5×10^6 Hz for SF_6, and other compounds in the same range.
MINIMUM DETECTABLE SAMPLE: Depends on sample species; approximately 0.1 picogram for Aldrin in a 1 second or shorter peak.
OVERALL SYSTEM TIME CONSTANT: 0.5 second.
NOISE: ~ 1 Hz/$\sqrt{Hz}$.
DETECTOR TEMPERATURE CONTROL: Automatic proportional control with ±0.1°C stability from +160°C to +320°C.

Detector Assembly Specifications

DIMENSIONS: 4-1/4" × 6-1/8" × 3-5/8" overall.
ASSEMBLY INCLUDES: Stainless Steel (Nitronic 60 alloy) detector block, heater block, platinum-resistor temperature sensor, over-temperature limit switch, thermal insulation, and aluminum housing.
INLET, OUTLET AND MAKE-GAS CONNECTIONS: 1/8" O.D., 6" inch long stainless steel tubing is supplied installed. Other sizes and materials are easily interchanged in the detector block using VALCO ZERO DEAD VOLUME 1/8" nuts and ferrules.
ANODE AND CATHODE CONNECTIONS: Coaxial BNC connectors with 5' cables supplied for connection between detector assembly and control unit.
HEATER AND TEMPERATURE SENSOR LEADS: 4-5 foot cable is supplied; extensions available.
MAXIMUM OPERATING TEMPERATURE: +320°C.
DETECTION VOLUME: 180 microliters.
TYPICAL CARRIER GAS FLOW: 60-100ml per minute of 95% argon/5% methane or nitrogen. Two-position switch permits optimizing pulse width for carrier gas selected.

Control Unit Specifications

DIMENSIONS: 4 5/8" × 8 1/4" × 11" overall
ELECTRICAL CONNECTORS: Detector anode (BNC); detector cathode (BNC); frequency output (BNC); recorder output (BNC); detector temperature control (4-pin); input power line cord (3-prong male), all located on rear apron.
OPERATOR CONTROLS: 16-position recorder output range switch, 10-turn baseline adjustment potentiometer, one-turn offset control, and detector temperature control; with the exception of a 2-position switch for optimizing pulse width for the carrier gas being used, all other controls are on front panel. Controls may be located remotely for custom installations.
INDICATOR LAMPS: Power "on/off" and heater power "on".
POWER REQUIREMENTS: 115 volt, 60 Hz, 100 watts maximum (including detector heater power).

Analytical Systems/Accessories

The 140B WRECD, installed on an existing chromatograph provides new chromatographic detection possibilities in analytical systems. The performance of such systems can be enhanced by the addition of other Valco products. For example, an automated four port post-column switching valve is often employed for selecting one of two detectors or venting of solvent peaks. For more information, see the Valco general catalog or consult the factory.

Ordering Information

VALCO MODEL 140B	Wide Range Electron Capture Detector — includes detector assembly, control unit, interconnection cables and 0-1mv output signal attenuator.
140B-3	Dual Output Attenuator with 0-1mv and 0-1V simultaneous outputs (or 10mv upon special order)
140B-4	Single Output Attenuator. Choose either 0-10mv or 0-1V.

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Portable GC—The most accurate and sensitive technique for toxic gas measurement

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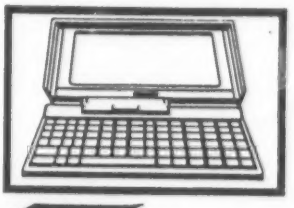

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  b. Computer monitor displays: Calibration and sample chromatograms, "overlay" of sample chromatogram on calibration chromatogram, all operator-computer dialog, diagnostic and concentration data (PPM/PPB)
  c. Integral software provides data summary from all runs, "TWA" summary including "min/max" and TWA values, storage and recall of up to 100 chromatograms from floppy disk
  d. Supports perpheral devices such as printer/plotter, communication modem, terminals and "slave" computers.

* Manual and automatic injection
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* Calibration by direct injection of standards or computerized calibration simulation
* Internal calibration and carrier gas supply cylinders
* Rechargeable 12 volt batteries
* Battery charger
* Recorder and alarm output
* Choice of standard column: (Please specify packing)
* Starter Kit: Including two refill copper tubing sets, two teflon tubing sets with fittings, allen key, recorder output plug, spare fuses, septa and instruction manual
* One year warranty
* Dimensions: 4" H X 19" W X 20" D
* Factory training course (one day) for up to three attendees at Sentex Factory, Ridgefield, N.J

RAPILOG LOGGER

HANDBOOK

ISSUE 1 DEC 1987

RAPCO ELECTRONICS
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1.0 INTRODUCTION

The RAPILOG data logger is enclosed in a stainless case with seven external connectors . Connections should only be made to approved devices as specified on the I.S. system drawing .

The power connector accepts power from an approved supply or battery .

The analogue output connector allows voltage output (to an approved voltage load) of recorded data or current channel voltage .

The data port connector accepts an opto connector from a data collection unit or from a 1144 interface unit and permits the transfer of data from the logger for more permanent storage and/or data analysis .

The four input channel connectors each accept eight differential input signals from transducers and supplies switched power to the transducers .

The data logger also houses a 32 character L.C.D. display and a keypad housed under a protective hinged lid. These allow programming and control of the full functions of the logger .

1.1 OPERATING FEATURES

A) UP TO SEVEN INDIVIDUAL RECORDINGS (FILES)

These files are independent of each other allowing the logger to be set up for multiple experiments .

B) SIX RECORD MODES FOR EACH CHANNEL

The record mode is independently selected for each channel in each file to enable the best use to be made of the data memory .

C) LARGE SELECTION OF SCAN RATES

A choice of 13 basic scan rates ranging from 100 samples per second to 1 sample every 2 minutes .

D) INPUT MONITOR AND ANALOGUE OUTPUT

This gives a direct voltage display of any selected input channel together with a voltage output that can be monitored by a chart recorder or similar if required .

E) RECORD PAUSE AND RESTART

This enables a recording to be halted temporarily for minor adjustments and then restarted .

F) REPLAY OF RECORDED DATA

This enables the recorded voltage data from any channel to be replayed onto Rapilog's display and simultaneously output as a voltage to a chart recorder or similar . The stored data is not affected by this operation.

1.1 OPERATING FEATURES continued

G) STORED IDENTITY CODES

This allows identification of channel details.

H) STORED TRANSDUCER DETAILS

This enables any subsequent analysis to represent stored voltage data in measured units .

I) STORED REFERENCE FOR EACH CHANNEL TRANSDUCER

This enables a 'base line' reference or offset to be stored for subsequent comparisons .

J) STORED FILE START AND RESTART TIMES

This automatically marks the time and date of a recording and enables time identification of all recorded data .

K) FILE EDIT AND OVERVIEW VIA THE KEYBOARD

This allows entry and alteration of all file parameters .

L) TRANSDUCER POWER SWITCHING

This enables power consumption to be reduced at slower scan rates .

M) LOW OPERATING POWER AND STANDBY MODE

This enables long recording times with standard battery units .

1.2 FILE CONTENTS

The set up information for each logging operation is contained in a file . There are seven independent files available in the logger allowing up to seven individual recordings to be made .

Each of the files contains the following :-

1) File Title - A four digit number for user identification of the recording

2) Scan Rate - The rate at which all the channels are sampled

3) Data Resolution - 10mV (8 bit) OR 2.5mV (10 bit)

4) Start Date & Time - Automatically entered from the internal clock

5) System Type - Automatically entered internal status information

6) Channel Information consisting of the following for each channel to be recorded :-

a) Channel Number - The number of the channel 1-32
b) Offset Voltage - Reference or offset voltage input
c) Transducer Type - Code representing the type
d) Transducer Range - Code representing the range
e) Identity Code - User code for transducer position
f) Voltage Range - Selects 0 to 2V or 0.4 to 2V range
g) Record Mode - Selects the channel recording mode
h) Parameters - Parameters for the record mode
i) Last Location - Automatically entered when halted

1.3 DATA STORAGE

A detailed understanding of the organisation of the solid state store is not required for normal usage of the RAPILOG system , since the storage space utilisation is automatic . However the choice of channel recording modes will affect the rate at which the storage space is used (see below) , and it is advisable to ensure that sufficient memory is available for the current application .

The data memory is divided into two functional areas . The first of these stores the memory allocation and the data for the seven file headers see 1.2 . This occupies 3K of the supplied data memory and the remaining area of data memory stores the recorded data . This is notionally divided into blocks which are assigned to a particular file and channel when a channel requires more data storage space while recording . This demand-paged memory allocation means that any one file may use the total available data storage area . A subsequent recording of another file is then free to use any of the remaining (un-allocated) data memory blocks .

In order to record a file , one data memory block must be available for each channel in the file . That is the data memory left must not be less than the total memory size multiplied by the number of channels in the file and divided by 256 . The data memory left and the data memory size are displayed when the LOGGER STATUS is selected , see 8.0 .

The amount of data stored for each sample is dependent on the channel recording mode and the file resolution .

In the record all mode each channel will use one data memory location (1 byte) for 8 bit resolution files , and two data memory locations (2 bytes) for 10 bit resolution .

In all other (conditional) channel recording modes each sample RECORDED uses four data memory locations . This is independent of the file resolution and thus to ensure a reduction of data memory used for a file the conditions set for the channel to record should only be met on average every fourth sample or less .

1.4 SCAN RATES

There are 13 basic scan rates which can be individually selected for each file . For each scan rate there is a maximum number of channels that can be recorded at that rate . This is due to the time taken to convert a sample to digital form and thus the maximum number of channels also depends on the selected resolution . A table showing the scan rates and maximum number of channels is shown below .

Scan Rate	Maximum Number of Channels	
	10 mV (8 bit)	2.5mV (10 bit)
100 per second	1	0
50 per second	2	1
20 per second	8	3
10 per second	17	7
5 per second	32	14
2 per second	32	32
1 per second	32	32
1 per 2 second	32	32
1 per 5 second	32	32
1 per 10 second	32	32
2 per minute	32	32
1 per minute	32	32
1 per 2 minute	32	32

The transducers are powered and all of the channels are scanned at this base rate . The channel data collected is compared with the channel recording mode parameters and the data is stored or not stored as required by the result of the comparison . See 1.5

1.4 SCAN RATES continued

For scan rates faster than 1 sample per second the transducers are continuously powered due to the settling time of the transducers . For rates of 1 sample per second and slower the transducer power is switched . This is arranged as 2 power switches one for channels 1 to 16 and one for channels 17 to 32 . If recording is not active on a channel within one of these two groups , then the power for that group will remain off .

NOTE:- The rate at which the power switching occurs has been set to match the response rate of the RAPCO preconditioned pressure and temperature transducers (types RAP 2570 , RAP 2590) . When other transducer types are employed the user should check that the response rate of the transducer and signal conditioning circuits are compatible or errors may occur at scan rates slower than 1 sample per second .

1.5 CHANNEL RECORDING MODES

Each channel in each file may be separately assigned to 1 of 6 different recording modes . The recording modes for a particular channel may be different in each file . The mode selected will affect the amount of data storage used for each sample stored . See 1.3

The recording modes are as follows :-

1) RECORD ALL - This mode has the additional qualifier of a divisor which can be preset in the range of 1 to 9999 . In this mode , although the channel is sampled at the base rate , the data is only stored at a rate equal to the base rate divided by the divisor (1-9999) . This allows the channels in a file to be recorded with different effective scan rates .

1.5 CHANNEL RECORDING MODES continued

2) RECORD CHANGE - This mode records data only if the last recorded sample and the current sample differ by more than a preset percentage (of transducer output voltage range). This can reduce the quantity of data stored for a slowly varying input .

3) RECORD BETWEEN - This mode records data only when the current sampled data is between the preset high and low percentage limits (of transducer output range) . This mode can reduce the quantity of data stored by only storing those values within the desired range . N.B. Fault conditions will not be recorded in this mode .

4) RECORD OUTSIDE - This mode records data only when the current sampled data is outside the preset high and low percentage limits (of transducer output range) . This mode can reduce the quantity of data stored by only storing those values which are outside the given range .

5) RECORD BELOW - This mode records data only when the current sampled data is below the preset low percentage limit (of transducer output range) . This mode can reduce the quantity of data stored by only storing values which are below the set threshold .

6) RECORD ABOVE - This mode records data only when the current sampled data is above the preset high percentage limit (of transducer output range) . This mode can reduce the quantity of stored data by only storing values which are above the set threshold .

1.5 CHANNEL RECORDING MODES continued

NOTE :-

Fault conditions , i.e. an input of greater than 2 volts OR less than 0.4 volts on a 0.4 to 2 volts transducer input range , will be recorded in all of the above modes EXCEPT the record between mode .

1.6 RECORDING TIME

The time for which a file will record is difficult to define absolutely as it depends upon the following variables :-

1) Data Memory left

This limits the number of data samples that can be recorded and due to the block organisation as described above when a channel is not granted a block of data memory the recording will stop .

2) Number of channels in a file

This limits the recording time as each channel requires a memory block to store data . Also the more channels that are connected , the more power will be required for the transducers and thus more power supply capacity will be required .

3) The base scan rate

This will affect the recording time in two ways . Firstly , a faster scan rate normally results in more data to be stored and thus a shorter recording time . Secondly , the base scan rate will affect the power taken from the supply to power the transducers . At scan rates faster than 1 sample per second the transducers are continuously powered and at slower rates the transducers are only powered for sufficient time to collect the data . See 1.4

1.6 RECORDING TIME continued

4) Channel recording mode

This affects the number of data memory locations used to store each data value and also the rate at which the data values have to be stored . See 1.3 and 1.5

5) File resolution

For channels in the record all mode , 10 bit (2.5mV) resolution will double the storage required compared with 8 bit (10mV) resolution .

6) Transducer input voltage

For channels in one of the conditional recording modes , the actual transducer input voltage when recording will vary the amount of data stored and thus the recording time . This is dependent on the number of times the transducer input signal meets the preset limit(s) .

7) Type of transducer

The physical type of transducer and interface circuitry will affect the power required and thus can influence the recording time when battery power supplies are used .

Unused transducers which are connected to the system can increase the power required , since power can be applied even if data is not being recorded . See 1.4

8) Battery power supply capacity

This will limit the recording time for some applications . Power is supplied to the logger and to the transducers (via the logger) and thus can be the limiting factor of the recording time .

1.6 RECORDING TIME continued

Some typical STORAGE LIMITED recording times are shown in the table below . Insufficient power supply capacity can reduce the times shown . All times shown are for a scan rate of 1 sample per second and the times can be linearly interpolated for other scan rates .

The table values assume that all of the channels are recorded in the same mode and that the conditions for recording are always met for the conditional recording modes i.e. the time shown is the absolute minimum time .

The mode for each channel is set individually and thus the recording time will be dependent on the application .

STORAGE LIMITED RECORDING TIMES at 1 sample per second

MEMORY SIZE	NUMBER OF CHANNELS	RECORD ALL MODE 8 BIT	10 BIT	OTHER MODES MINIMUM
64 K	1	17H 12M	8H 36M	4H 18M
64 K	8	2H 8M	1H 4M	32M
64 K	16	1H 4M	32M	16M
64 K	32	29M	14M	7M
256 K	1	71H 40M	35H 50M	17H 55M
256 K	8	8H 49M	4H 24M	2H 12M
256 K	16	4H 16M	2H 8M	1H 4M
256 K	32	1H 59M	59M	29M

Some typical POWER SUPPLY limited recording times are shown in the table below . The times shown are per Ampere Hour capacity for standard and pre-conditioned transducers.

POWER LIMITED RECORDING TIMES per AH

SCAN RATE	PRE-CONDITIONED 8 CH	32 CH	STANDARD 8 CH	32 CH
1 per sec	25H	11H 20M	12H 30M	4H
1 per 10s	45H 20M	37H 10M	38H 20M	23H 20M
1 per min	49H 10M	47H 20M	47H 30M	42H 10M

2.0 OPERATION

The keyboard and display combine to make the LOGGER operation relatively easy and yet retain the flexibility required .

The keyboard contains 14 active keys , 0 to 9 for numeric data entry , 'E' for entering data or selecting functions , up and down arrow keys for selecting next or previous functions .

The display shows the current state of the logger operation and in the bottom right of the display , the NEXT (permitted) KEYS to initiate the next sequence . The logger operation is based on the user selecting a function from a menu of functions . In this mode a downward pointing arrow and 'E' are displayed as the next keys . Pressing the down arrow key will display the next selection from the menu and pressing the 'E' key will enter the desired function or value as displayed .

When numeric data entry is required a flashing cursor will be displayed at the entry point on the display . Numeric data entry is automatically justified and limited to the input range allowed . If an error is made when entering data continue entering data until the display shows the desired value and then press 'E' to enter .

2.1 When the LOGGER is turned on the data memory is automatically checked . If the memory data has not been retained the display will indicate that the data memory has an error and pressing the down arrow key will reset the data memory and allow operation to continue with a 'clean sheet' .

When the data memory has been retained the display will show the 'sign on' message (RAPCO RAPILOG) and the time and date . This display is returned to on completion of a main menu function as described below . Pressing the down arrow key will replace the date and time display with the first function from the main menu . The desired main menu function may now be selected as described above .

2.0 OPERATION continued

2.2 The main menu functions are as follows :-

1) Set time & date - set the internal clock
2) Monitor - display channel or supply voltages
3) File Header - set or change the file information
4) Record File - start data logging operation
5) Replay File Data - display the recorded channel data
6) Logger status - display the current logger state
7) Transfer data - transfer data via the opto link
8) Erase data - erase data and reset file headers
9) Power off - minimise power for disconnect

The LOGGER commands are detailed in the following individual sections (3.0 to 11.0) .

3.0 SETTING THE TIME

This function enables the date and time of the internal real time clock to be set . The clock is supported by an internal battery and thus should only require setting if the support battery is allowed to discharge or if an adjustment is required .

Selection of this function will result in the display prompting for the entry of the month (1 to 12) . The cursor will be flashing to indicate that numeric entry is required . Key in the month 1 to 9 ,10,11 or 12 and then the 'E' key to enter.

The display will now prompt for the day of the month with a flashing cursor as before . Key in the day of the month (within the limits shown) and then 'E' to enter .

The display will now prompt for the entry of the hour (0 to 23) with a flashing cursor . Key in the hour and then 'E' to enter .

The display will now prompt for the entry of the minutes (0 to 59) with a flashing cursor . Key in the minutes and then 'E' to enter . NOTE:- The seconds are automatically set to zero when the minutes are entered .

The set time function is now completed and the 'sign on' message will be displayed with the new time .

4.0 MONITOR

This function enables the power supply or an input channel voltage to be displayed .

Selection of this function will result in a monitor menu to be displayed . This allows the selection of channel monitor , supply monitor or return to the main menu (exit from the monitor function) .

When channel monitor is selected the flashing cursor appears on the display to prompt for the entry of the channel number to be monitored . Key in the channel number and then 'E' to enter . The display will now show MONITOR ON , the channel number and the voltage on that channel . The displayed resolution is 10mV and the display is updated two times a second . The channel voltage is also available on the monitor output connector . The transducer power is only turned on when the channel voltage is sampled and turned off when returned to the monitor menu .

When supply monitor is selected the display shows MONITOR ON and the supply voltage with 100mV resolution . The monitor output will remain at zero while the supply is monitored .

When the monitor is on , the next key display shows the up arrow and pressing this key will turn off the monitor and return to the monitor menu .

The main logger menu is returned to by selecting the RETURN TO MENU function from the monitor menu .

5.0 SETTING FILE HEADER

This function permits the setting , editing and reviewing of file parameters .

Selection of this function results in the display prompting for the entry of a file number (1 to 7) . Key in the desired file number and then 'E' to select the file .

If the selected file has already been recorded the display will show a message to this effect and the down arrow key will return to the main menu . If modification and/or rerecording is desired then the data recorded has to be erased . See 10.0 .

If the selected file header has been previously set then at each stage of the setting procedure (see below) the previously set data will be displayed allowing this to be entered or amended as required .

If the selected file has not been set or recorded then default values of zero are used for numeric entry and default menu selections will be shown .

If file 0 is selected (by pressing 'E' in response to the file number prompt) then provided a pre-programmed file header is available , this is copied to the first free file (of the seven) available . Subsequent operations are then performed as if the file is set . If a pre-programmed file header is not available or if all seven files are either set or recorded then the display will return to the main menu .

The first parameter to be set in the file header is the file title which consists of a 4 digit number used to identify the file and defined by the user .

The next parameter to set is the base sample rate , see 1.4 . This sets the basic scan rate of the logging operation i.e. the minimum time resolution . The selection of the scan rate is via the scan rate menu which is available via the down arrow key . When the desired rate is displayed , pressing the 'E' key will select the rate shown . The default rate is 1 sample per second .

5.0 SETTING FILE HEADER continued

The next parameter to enter is the file resolution . This is selected from a menu of 10mV (8 bit) and 2.5mV (10 bit) resolutions . The resolution selected can affect the number of data storage locations used to store a reading from a channel and the maximum number of channels that can be recorded in the file due to the analogue to digital conversion time . See 1.4

When the resolution has been selected by the 'E' key the display will show the maximum number of channels that can be recorded (or set in the file) with the selected scan rate and resolution . Scan rates of 2 samples per second or slower will always allow recording of 32 channels

NOTE :- The maximum number of channels displayed does not affect which channels can be recorded but only the total number of channels that can be recorded . It is advantageous to only set those channels that are required so as to minimise the data storage used .

The display will show both an up and a down arrow as the next keys , the up arrow key will return to the scan rate selection to allow for correction and the down arrow key will move onto the channel parameter section .

5.1 Channel Parameters

On entry to this section of a previously set file header the first channel set in the file header will be displayed with a down arrow and 'E' as the next keys . Pressing the down arrow key will skip the displayed channel parameters and display the next channel in the file header.

Pressing the 'E' key will enter the channel and allow examination and modification of the channel parameters as detailed below . If no further channels are set in a file header the display will prompt for an additional channel as below . If all of the available channels have been displayed the display will return to the main menu .

If the file header has not been previously set then the display will prompt for an additional channel .

The ADD CHANNEL? display is accompanied by a menu to select yes or no . If no is selected then the display will return to the main menu .

5.0 SETTING FILE HEADER continued

When a channel is to be added the display prompts for the entry of the channel number (1 to 32) . Selection of a channel that is already set in the file header will result in a display to this effect and a down arrow as the next key . Pressing the down arrow will return to the ADD CHANNEL? display . Entering a channel number of 0 or greater than 32 will also return to the ADD CHANNEL? display .

Entry of a valid channel number results in the display prompting for offset entry. This is a method of storing a single voltage value from the transducer as a reference value for subsequent analysis . Selecting channel offset will result in the present channel voltage being displayed. Pressing the 'E' key will store the value displayed or pressing the down arrow key will set the value stored to zero .

If the offset entry option is not selected then , for a previously set file header the voltage is retained at it's previously set value , and for a new file header the value stored is zero .

The display will now prompt for the selection of the transducer type . This is selected from a menu of types and selection of an undefined type will skip the subsequent range selection .

The display will now prompt for the selection of the transducer range . This is selected from a menu of ranges for each type as above .

The display will now prompt for the channel identity code . This is a user definable 2 digit number (0 to 99) which may be used to annotate the position of a transducer. The default value is zero .

The display now prompts for the transducer voltage output range . This is selected from 0 to 2V or 0.4 to 2V ranges in a menu . This information is used for subsequent analysis and for setting the percentage limits for the conditional recording modes as described in 1.2 and below .

NOTE :- 50% of a 0 to 2V output transducer is 1V
50% of a 0.4 to 2V output transducer is 1.2V

5.0 SETTING FILE HEADER continued

The display will now prompt for selection of the channel recording mode from the menu of recording modes . The recording mode is independently selected for each channel and is also independent of the mode set for that channel in any other file header . See 1.5

1) RECORD ALL

This mode enables recording of data at a selected rate and all data is recorded . Entry of this mode will then prompt for the entry of the base scan rate divisor . This allows the sample rate for the selected channel to be reduced . The divisor can be any value from 1 to 9999 allowing a large variation in sample rates between channels in this mode .

2) RECORD CHANGE

This mode records data only if the current data sample differs by more than a preset percentage from the previously recorded data . Entry of this mode will prompt for the entry of the percentage change parameter .

3) RECORD BETWEEN

This mode records data only when the current data sample lies between the preset percentage limits . Entry of this mode will prompt for the entry of the low percentage limit parameter followed by a prompt for the entry of the high percentage limit parameter .

NOTE :- Fault input voltages will not be recorded in this mode .

5.0 SETTING FILE HEADER continued

4) RECORD OUTSIDE

This mode records data only when the current data sample lies outside the preset percentage limits . Entry of this mode will prompt for the entry of the low percentage limit parameter followed by a prompt for the entry of the high percentage limit parameter .

5) RECORD BELOW

This mode records data only when the current data sample is below the preset percentage limit . Entry of this mode will prompt for the entry of the low percentage limit parameter .

6) RECORD ABOVE

This mode records data only when the current data sample is above the preset percentage limit . Entry of this mode will prompt for the entry of the high percentage limit parameter .

NOTE : In the above modes the percentage limit refered to is the percentage of the transducer voltage output range as described above .

The display will now return to the ADD CHANNEL? prompt . Selecting an additional channel allows selection of a further channel and repetition of the above setting procedures for that channel . If no further channels are permitted due to the maximum channel limit the display will return to the main menu . When all of the required channels have been set , the ADD CHANNEL? option may be declined and the display will return to the main menu .

The file header is now set and is ready to record .

6.0 RECORDING FILES

This function starts the data logging sequence . Transducer power is automatically switched on and off for base scan rates of 1 sample per second and slower . While the logger is recording each of the channels being recorded may be selectively monitored on the display and the monitor output connector . The recording may be paused and subsequently restarted any number of times to allow (for example) capture of transient events . The start and restart times are automatically recorded for subsequent analysis .

Selecting the RECORD FILE function will result in the display prompting for the selection of a file number (1 to 7) . Keying a file number and then 'E' to enter , will select a file . If the selected file has not been set, an appropriate error message is displayed and pressing the down arrow key will return the display to the main menu .

If file 0 is selected (by pressing 'E' in response to the file number prompt) then if a pre-programmed file header is fitted then this is copied to the first free file (of the seven) available and the record operation will then commence on that file . If a pre-programmed file header is not available or none of the files are free then the display will return to the main menu .

The display now prompts for the entry of a 4 digit security code . This can be used to prevent unauthorised access to the logger functions while the logger is recording . See 6.1 and 6.2

The display now shows READY TO RECORD and a menu of start recording or return to menu will be displayed . Selecting return to menu will return to the main menu . Selecting start recording will start the recording of data for the specified file and enter the start time . The display will now show that the file is being recorded and the record menu will be displayed allowing selection of MONITOR , LOCK , PAUSE and STOP .

6.0 RECORDING FILES continued

The recording menu functions are :-

1) MONITOR

Selection of this function will display the first channel in the file and the voltage of that channel's input . Up and down arrows are displayed as the next keys . Pressing the down arrow key will advance the monitor to the next channel which is being recorded .

If the panel lock has not been previously selected , i.e.the panel is in the unlocked state, then pressing the up arrow key will return to the recording menu .

In the panel lock mode , the 4 digits of the security code followed by the up arrow key are required to return to the unlocked state and the recording menu .

NOTE :- The display of the voltage may be delayed due to waiting for the next sample to be taken . This can be a delay of up to two minutes at the slowest base scan rate .

2) LOCK - nnnn

When the lock function is displayed the security code nnnn , previously entered at the start of recording , is also displayed .

Selection of this function will invoke the panel lock and the monitor display will be shown . Entry of the security code nnnn followed by the up arrow key is now required to return to the unlocked state and the recording menu . The panel lock is automatically reset when the data memory becomes full or the power supply is disconnected .

NOTE :- All 4 digits nnnn as displayed on selection of the lock function have to be entered .

6.0 RECORDING FILES continued

3) PAUSE

Selection of this function will pause the recording of data . The transducer power will be removed and a sub menu of RESTART and STOP will be displayed .

RESTART

Selecting this function will record the restart time and resume recording of the file , the display will return to the monitor , pause and stop menu .

4) STOP

Selection of this function will cause the data logging function to stop and the display to return to the main menu .

If the supply cannot provide sufficient power to maintain logging then the data logging will automatically stop with no loss of recorded data .

If the power supply is abruptly removed during a logging operation the recorded data will be incomplete and may be irretrievable .

The data memory is not subdivided for each file and thus the recording file will use data memory as necessary to record the channel data . If the file is not stopped before all of the data memory is used then the display will show DATA STORE FULL . Pressing the down arrow key will return to the main menu . Any remaining unused data memory is available for recording data from other files .

7.0 REPLAY OF DATA

This function allows the replay of recorded data as a displayed voltage and as an analogue signal on the analogue output connector .

Selection of this function will prompt for the entry of the file number (1 to 7) . Keying in a file number and 'E' to enter will select a file . If the file selected has not been recorded then NO DATA RECORDED will be displayed and pressing the down arrow key will return to the main menu .

The display will now prompt for the selection of a channel or returning to the main menu . Selecting return to the menu will return to the main menu . Selecting a channel to output will then prompt for the selection of a channel number . Selecting a channel that has not been recorded in the selected file will return to the select channel/return to menu option as above .

Selecting a valid channel number will cause the replay rate menu to be displayed . This allows 4 different replay rates for the recorded data as follows :-

1) NORMAL
   This selection outputs the data at the recorded rate .

2) FAST
   This selection outputs the data ten times faster than it was recorded . If the recording rate was faster than 10 samples per second then the replay rate is fixed at 100 samples per second .

3) SLOW
   This selection outputs the data ten times slower than it was recorded . If the recording rate was slower than 1 sample per 5 seconds then the replay rate is fixed at 1 sample per 2 minutes .

4) 10 SAMPLES PER SECOND
   This selection outputs the data at a fixed rate of 10 samples per second .

7.0 REPLAY OF DATA continued

Selection of the rate is accomplished by pressing the down arrow key until the desired rate is displayed and then pressing 'E' to enter the rate .

The recorded data will now be displayed and output to the analogue monitor output . If the up arrow key is pressed the output will stop (monitor output set to zero) and the select channel/ return to menu option will be displayed as above .

If a file has been paused and restarted then RESTART will be displayed with up arrow and 'E' as next keys . Pressing the up arrow key will display the select channel/ return to menu option as above . Pressing the 'E' key will allow reselection of replay rate and then continue with the data output .

When the end of the recorded data is reached the monitor output will be set to zero and the select channel/ return to menu option will be displayed .

8.0 LOGGER STATUS

This function permits the current status of the data memory and the seven files to be examined .

Selection of this function will display the data store size fitted and a down arrow as the next key .

Pressing the down arrow key will display the amount of data memory left i.e. the amount of remaining data memory that can be used for recording file data .

Pressing the down arrow key will then step through each of the seven files in turn and indicate their status

1) FREE - The file has not been set or recorded

2) SET - The file has been set and is ready to record

3) USED - The file has been set and recorded

When the seventh file is displayed pressing the down arrow key will return to the main menu .

9.0 TRANSFER DATA

This function permits recorded data and file header data to be transferred to the data collection unit or to the computer interface unit .

Selection of this function will initiate communication with the logger and thus connections should be made before selecting this function .

If the logger is connected to a data collection unit the display will prompt for the selection of DUMP or LOAD

1) DUMP

Selection of this function will copy all recorded data from the logger to the data collection unit . While the data transfer is active a count of data blocks left to transmit will be displayed .

2) LOAD

Selection of this function will copy all of the file set up data from the data collection unit to the logger .

On completion of the data transfer the display will return to the main menu . The time taken to dump data to the collection unit is dependent on the amount of data memory used . A fully used 64K logger will dump data in approximately 50 seconds .

If the logger is connected to the computer interface then all communications will be controlled by the computer interface . Communications can be aborted in this mode by pressing the down arrow key but the validity of the transfered data cannot be assumed .

10.0 ERASING DATA

This function enables recorded data to be erased and gives the option to erase set file headers .

Selecting this function results in a confirmation display to avoid inadvertent erasure which allows return to the menu or erasing the data .

Selection of erase ,erases all of the recorded data and changes the status of all recorded files to set . This permits re-recording of files without resetting them .

The display now gives the option of erasing the file header data of all of the set files . Erasing the file header data will return the file to the free state .

After the last set file has been shown , the display will return to the main menu .

11.0 POWER CONTROL

This function allows the logger to be turned off to minimise the disconnect current . The supply may be restored by pressing the GREEN (on) key .

The supply may be removed without selecting the power off function without damage to the logger but subsequent connection of power will automatically restore power to the logger .

If the supply voltage falls below a minimum value during a recording the data will be saved due to the separate data support battery .

12.0 SPECIFICATION I.S Certification No. IS 11369

Mechanical - Enclosed Stainless Steel Case

Finish - Natural , engraved lettering

Size - Width 265mm
Depth 180mm
Height 110 mm excluding connectors

Weight - 5.1 Kg approx

Power - External D.C. supply
Use only approved power supplies as specified

Electrical -

Recorded Channel Input Voltage	0 - 2.5 Volts
Maximum Channel Input Voltage	0 - 5 Volts
Monitor Output Voltage	0 - 2.5 Volts
Recording Resolution	2.5mV or 10mV
Sample Clock Accuracy	0.03%
Real Time Clock Accuracy	0.03%
Data Memory Size	64K or 256K
Data Memory Retention Time	30 Days

13.0 INSTALLATION

The RAPILOG system is constructed for use in harsh enviroments but care should be taken wherever possible .

The internal data support battery should be kept charged and the logger should be powered for a minimum total period of 24 hours in every month to keep the data support battery charged .

The protective socket caps should be kept in place on the connectors whenever the connectors are not in use .

Cables should be routed away from the path of moving machinery as should the logger itself to avoid damage . Rapilog and other system components are sealed against water splash but excessive exposure to water must be avoided .

13.1 CONNECTIONS

Seven connectors are situated on the front panel six of which provide electrical connections and one provides optically isolated communications .

1 - Power Input Connector - 2 pin Fischer type

pin 2 - positive supply
pin 1 - supply return

2 - Auxiliary Connector - 8 pin Fischer type

pin 1 - Analogue output monitor
pin 2 - Analogue output return
pin 3 - Contact closure input
pin 4 - Contact closure return
pin 5 - N/U
pin 6 - N/U
pin 7 - N/U
pin 8 - N/U

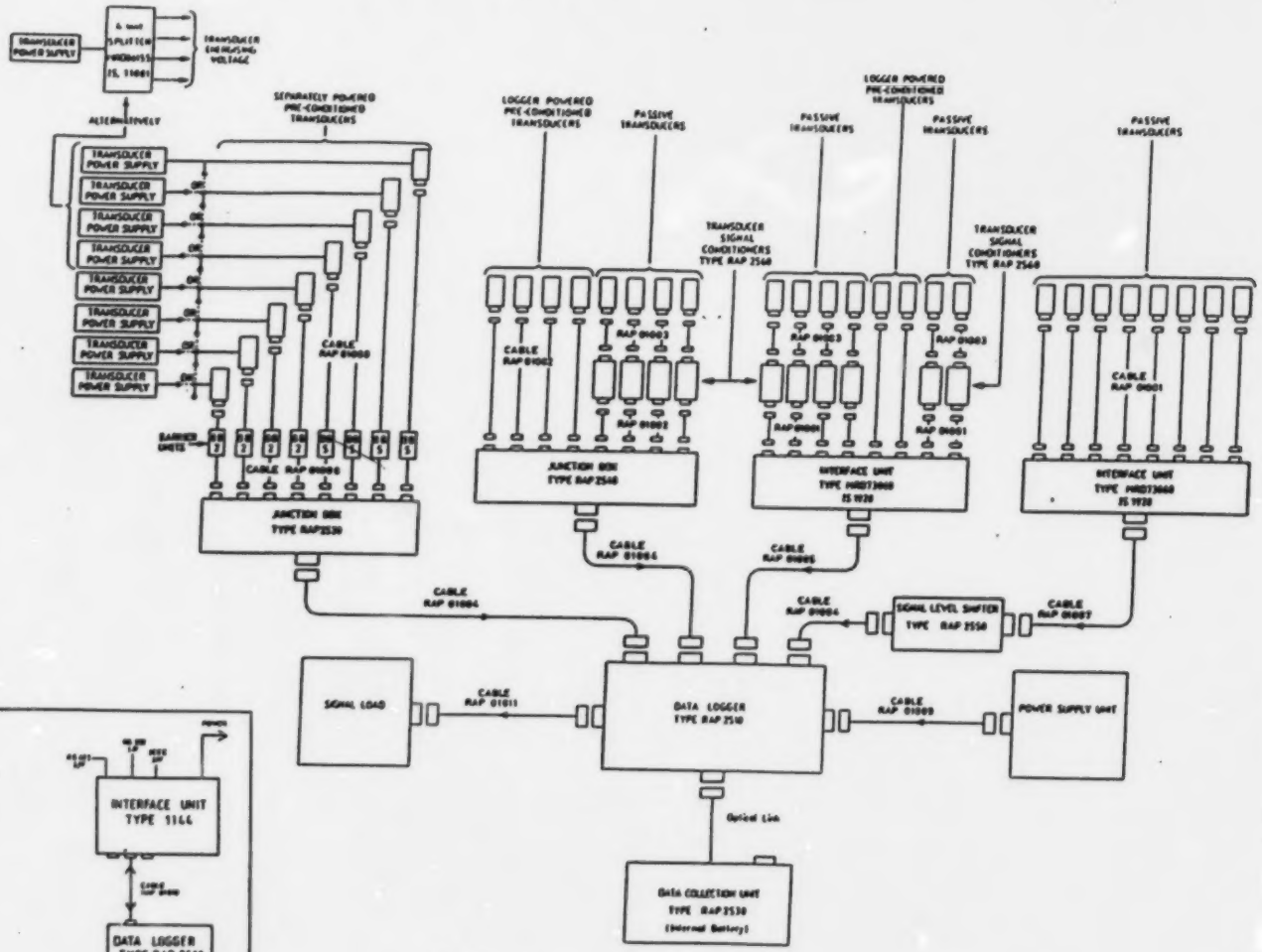
3 - Opto Connector - Lemo type

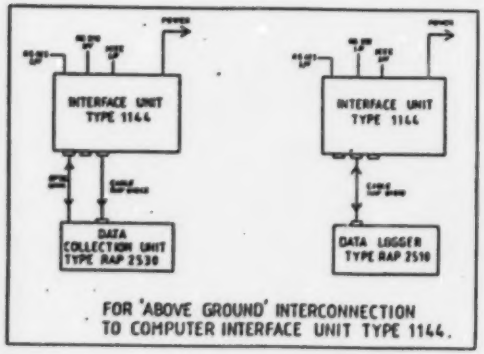
Modified by Rapco to provide optical communications to the data collection unit and computer interface.

4,5,6,7 - Input Connector - 18 pin Fischer type

pin 1 - Transducer power
pin 2 - Channel 8 return
pin 3 - Channel 8 signal
pin 4 - Channel 7 return
pin 5 - Channel 7 signal
pin 6 - Channel 6 return
pin 7 - Channel 6 signal
pin 8 - Channel 5 return
pin 9 - Channel 5 signal
pin 10 - Channel 4 return
pin 11 - Channel 4 signal
pin 12 - Channel 3 return
pin 13 - Channel 3 signal
pin 14 - Channel 2 return
pin 15 - Channel 2 signal
pin 16 - Channel 1 return
pin 17 - Channel 1 signal
pin 18 - Transducer power return

RAPILOG SYSTEM INTERCONNECTION OPTIONS AND CABLING DETAILS.




INTERFACE UNIT TYPE 1144
INTERFACE UNIT TYPE 1144
DATA COLLECTION UNIT TYPE RAP 2530
DATA LOGGER TYPE RAP 2510
FOR 'ABOVE GROUND' INTERCONNECTION TO COMPUTER INTERFACE UNIT TYPE 1144.

G40

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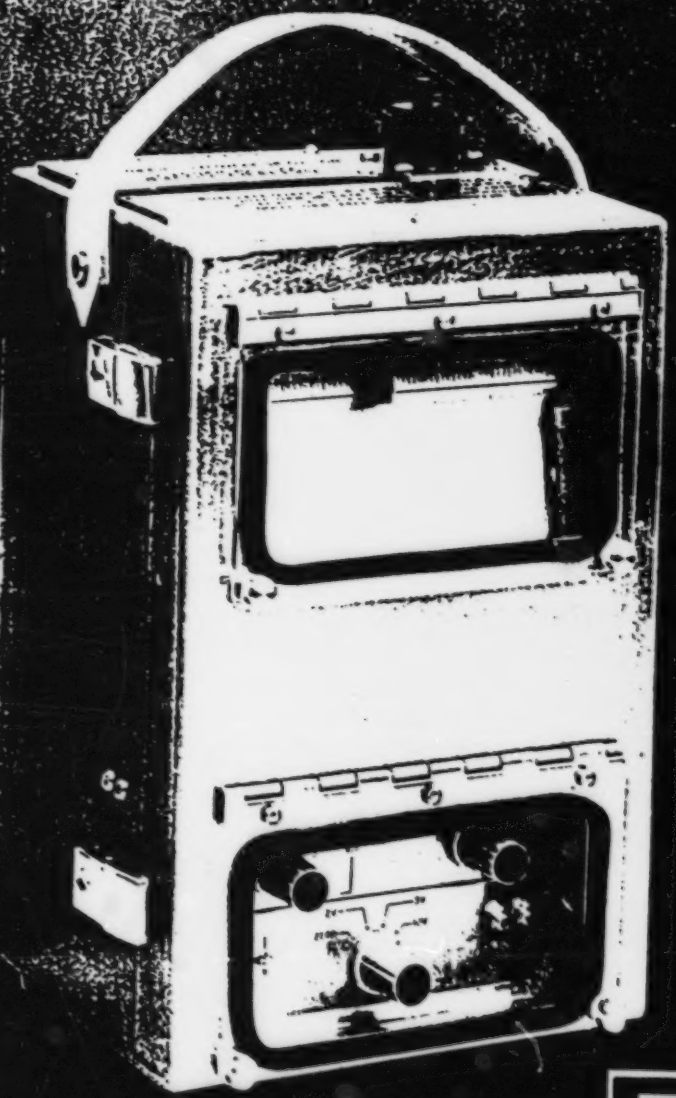
10 JOULE ROAD, BASINGSTOKE, ENGLAND.

26.11.87



PORTABLE INTRINSICALLY SAFE CHART RECORDER

Designed and Manufactured in the U.K. by

Rapco

ELECTRONICS LTD.

JOULE ROAD, HOUNDMILLS,
BASINGSTOKE, HANTS, ENGLAND RG21 2XF
Tel: Basingstoke (0256) 25454

GENERAL DESCRIPTION

This precision, single pen recorder originally developed for M.R.D.E. is specifically designed for use in rugged underground environments with methane atmospheres. The instrument has intrinsic safety approval as defined in British Standard 1259–1958.

Housed in all-welded stainless steel case, the unit weighs only 4.9kg (10.8lbs) complete with internal battery. It is, therefore, extremely portable and the unique combination of facilities make the recorder ideal for many applications in areas other than mining.

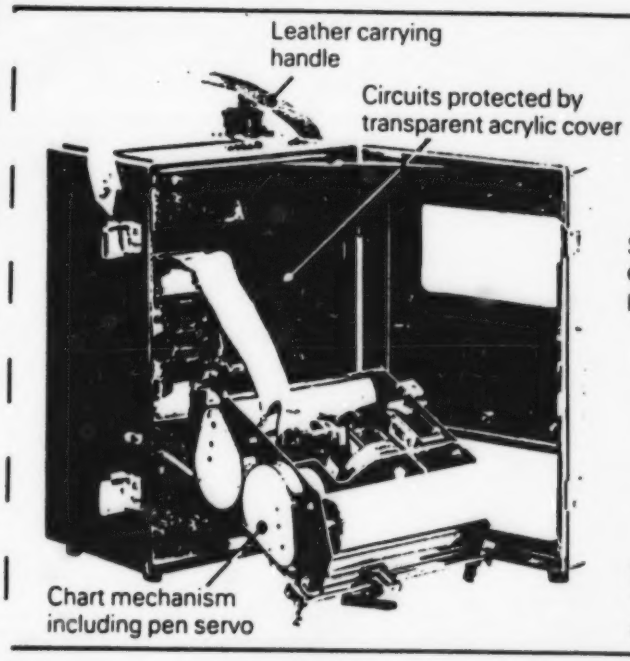
There are ten electrically switchable crystal controlled chart speeds, covering a very wide range of speeds from 12mm per hour to 12 metres per hour. A solenoid operated pen marks the lower chart margin to indicate the selected chart speed.

Standard 120mm x 15 metre chart rolls are used.

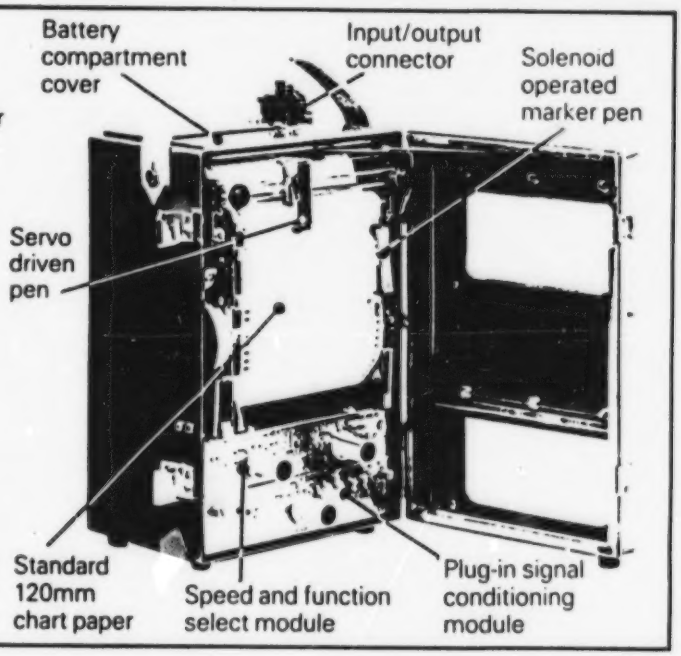
Plug-in signal conditioning modules for voltage, current, frequency and strain gauge inputs are available.

Comprehensive self test and calibration facilities are included.

The unit may be powered from an external d.c. source if required.



Recorder with lid open and chart mechanism hinged down for access to chart roll



Recorder with lid open illustrating some of the major components

ELECTRICAL SPECIFICATION

Signal Conditioning Modules

(1) Voltage Module

MRD 77113

Input	Differential
Input Impedance	200kΩ
Input Voltage Range	Switchable Zero (input short circuited) 0–2V full scale 0–5V full scale 0–10V full scale (Note that on the 10V range, input protection diodes will limit the range to approximately 9V. Input impedance is approximately 2kΩ when diodes conduct).
Zero Adjustment	By means of a preset potentiometer on the front panel.
Gain Adjustment	By means of a preset potentiometer on the front panel.
Calibration	Internally derived 2V. A biassed toggle switch on the front panel selects the calibration voltage. The module input is open circuit when the calibration voltage is selected.

(2) Current Module

MRD 77115

Input	Differential
Input Impedance	180kΩ
Input Current Range	7.5mA full scale. Input protection diodes are incorporated.
Zero Adjustment	By means of a preset potentiometer on the front panel.
Gain Adjustment	By means of a preset potentiometer on the front panel.
Calibration	Internally derived. A biassed toggle switch on the front panel selects the internal calibration equivalent to 7.5mA full scale. During calibration the input module impedance is 180Ω but is disconnected from the internal circuits.

(3) Speed Module

MRD 77117

Speed Selection	10-position rotary switch on the front panel giving 10 crystal controlled chart speeds of 12, 30, 60, 120 and 300mm/hr and 0.6, 1.2, 3, 6 and 12M hr.
Function Switch	4-position rotary switch with the following positions: OFF All recorder functions and power are switched off. BATT CHECK Enables a check of battery voltage to be made. A scaled voltage derived from the battery is applied to the pen drive. The chart drive mechanism has power applied in this mode. PEN CHECK Enables a check to be made of correct operation of the pen drive in conjunction with the signal conditioning module. The chart drive mechanism does not have power applied in this mode. RUN Normal operating position.

(4) Current Module (Variable Filter) MRD 77215

This plug-in module is intended for use where the transducer output has a large a.c. content e.g. unsmoothed full wave rectified 50Hz. The module contains a low pass filter, the cut off frequency of which may be selected to suit the application. The module output is proportional to the mean value of the input signal.

Input	Differential
Input Impedance	180Ω
Input Current Range	0–7.5mA
Filter Cut/off Frequency	Switchable 0.2Hz 1Hz 5Hz 10Hz
Calibration	Internally derived 7.5mA. A biassed toggle switch on the front panel selects the calibration current. The input signal is disconnected when calibrate is selected.
Zero Adjustment	By means of a preset potentiometer on the front panel.
Gain Adjustment	By means of a preset potentiometer on the front panel in conjunction with the Calibrate switch.

(5) Strain Gauge Module

MKII–MRD 77158 Is for use with transducers in the sensitivity range 1.2mV/V to 42mV V and provides a larger range of zero offsets than did the Mk1 version.

MKIIA–MRD 77068 Is for use with transducers in the sensitivity range 0.12mV/V to 4.2mV V.

	MRD 77158	**MRD 77068**
Input	Differential	Differential
Input Impedance	>200KΩ	>20KΩ
Input Polarity	Switchable Normal or Invert	Switchable Normal or Invert
Input Sensitivity (coarse)	Switchable x0.3 x1 x3	Switchable x0.03 x0.1 x0.3
Input Sensitivity (fine)	10 turn Vernier potentiometer scaled 4.00 to 14.00	
Output Voltage to Bridge	4.00V	4.00V
Bridge Impedance	>250Ω	>250Ω
Zero Adjustment	10 turn Vernier potentiometer scaled 0.0 to 10.0 (enables pen to be zeroed to any point on the chart).	
Calibration	No internal calibration is supplied but the controls enable the user to set the required gain if the transducer sensitivity is known.	

ELECTRICAL SPECIFICATION (continued)

(6) Frequency Module MRD 77036

This plug-in module is for use with turbine type flowmeter transducers. The module will accept signals as low as 10mV but the IS Certificate limits the maximum allowable transducer output to 26V.

Input

Differential

Input Impedance

100kΩ

Input Sensitivity

Not less than 10mV rms for correct operation.

Input Frequency Range

Switchable 0–100Hz
0–200Hz
0–500Hz
0–1kHz
0–2kHz
0–5kHz

Calibration

An internal crystal oscillator generates a precise full scale reference frequency signal. A biassed toggle switch on the front panel selects the reference signal. The input signal is disconnected when calibrate is selected.

Zero Adjustment

By means of a preset potentiometer on the front panel.

Gain Adjustment

By means of a preset potentiometer on the front panel in conjunction with the Calibrate switch.

(7) Calibration Module MRD 77079

The RAPCO Calibration Module Type MRD 77079 is designed to plug into the input module position on the RAPCO PCR1 Recorder. It generates precise zero and full scale signals to enable the user to correctly reset the zero and gain controls on the recorder's motherboard should they need adjustment at any time. THE MODULE IS SPECIFIED FOR SURFACE USE ONLY.

GENERAL SPECIFICATION

Pen Movement

Linear. Full scale 100mm.

Pen Response

0.5 secs. for full scale (100mm) with battery/power supply at 9V. Performance degrades with reducing supply voltage and is improved with less than full scale signals.

Accuracy

±2% of full scale.

Event Pen

Writes a 3mm (approx.) vertical line on the lower chart margin at intervals related to chart speed as follows:

Speed	Interval in mm
12mm/hr	3
20mm/hr	7.5
60mm/hr	15
120mm/hr	30
300mm/hr	75
0.6M/hr	5
1.2M/hr	10
3M/hr	25
6M/hr	50
12M/hr	100

Power

(a) Battery Type PP9 or VT9 (9V).
(b) External d.c. supply via POWER SUPPLY ADAPTOR MODULE Type MRD 77121. Maximum voltage 16V. Use only approved external power supplies:

DC2 MRD 52352	
BAT. 1 MRD 55727	MRD. 68187
BAT. 2 MRD 55729	MRD. 98550
BAT. 1 with DC3.	12V DC or 18V DC to BS. 6182 PT 1

Input/Output Connector 4 pin connector Plessey Mk. 7 Brass with dust cap and chain. Mating free plug (supplied) 508/1/07222/220.
Connections:

PIN B	Non inverting input
PIN C	Inverting input
PINS A & D	Reserved for strain gauge energising voltage.

NOTE: Only approved transducers as per MRD 771100 Sht. 1 may be used.

MECHANICAL SPECIFICATION

Case

Stainless steel, all welded construction. Hinged lid with sealing gasket. Lid closed with two lockable catches. Removable leather carrying handle. Hinged acrylic windows in lid for access to controls and chart.

Dimensions: Height 258mm
Width 170mm
Depth 146mm
Weight 4.9kg including battery.

Chart Roll

Standard 120mm wide x 15M long chart roll to DIN 16230. Chart printed 100mm wide. The following scale types are available:

TYPE 1. For general purpose use. Scaled 0-100 full scale.
TYPE 2. Scaled 0-100 but with zero offset. Suitable for use with 0.4V to 2V transducers.
TYPE 3. Scaled 800-1200. Suitable for use with power transducers.

Pen Cartridge

Graphic Controls Corp. Series 39 available in Black (Type 39/101)
Red (Type 39/102)
Blue (Type 39/103)
Green (Type 39/104)
Purple (Type 39/106)

Unless otherwide requested, a RED pen cartridge will be fitted to the Servo Pen Carriage and a BLACK pen cartridge to the Event Marker Carriage.

Rapco's policy is one of continual improvement. We therefore, reserve the right to change this Specification without notice.

APPENDIX H

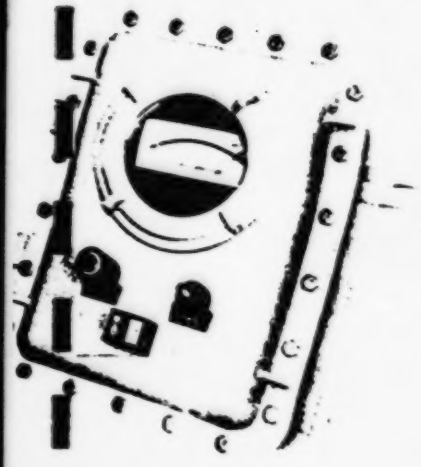
Explosion-proof Enclosures and Accessories

EXPLOSION-PROOF CONTROL ENCLOSURES

XCE Series

CLASS I, GROUPS C & D; CLASS II, GROUPS E, F, & G
NEMA 3, 4 (OPTIONAL)*, NEMA 7, 9

Drilled and tapped to specification for installation of operators and windows**
CSA Certifications Available
(Consult Factory)



Typical XCE

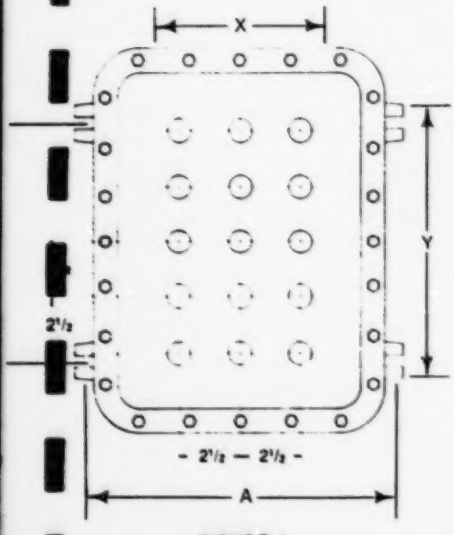


FIGURE 1

* Suitable for NEMA 3, 4 raintight, watertight locations. Add suffix N4 to catalog number.

** Consult factory or attach layout sheet for combination of window and operator installation.

ACCESSORY SELECTION:

Recommended operators, windows, hinges and accessories, refer to following pages.

Spacing information for operators in cover or back of the box. (Fig. 1)

- All operator holes are tapped ¾" NPSM. Operators are laid out from center line of enclosure.
- The spacing shown provides ample electrical clearances and easy assembly. If more operators are required consult factory.
- When operators are cover mounted, covers should be hinged to avoid damage to wiring when opening.
- CSA certification available on most control enclosure drilling and tapping configurations.

MAXIMUM WALL THICKNESS 13/16" WILL ACCOMMODATE SHORT STYLE EXPLOSION PROOF OPERATORS IN COVER AND BACK. HEAVIER WALLS REQUIRE LONG STYLE OPERATORS.

For additional dimensional data, refer to page XCE-36.

EXPLOSION-PROOF CONTROL ENCLOSURES

XCE Series

CLASS I, GROUPS C & D; CLASS II, GROUPS E, F, & G; NEMA 3, 4 (OPTIONAL)*, NEMA 7, 9

Dimensions in Inches

Catalog Number	Inside Nominal Dimensions W L D	Mounting Nominal Dimensions A	B	Operators Per Row (See Figure 1) X	Y	Lug Bolt Size	Wall Thickness	Shipping Weight, Pounds
XCE-080804	8 x 8 x 4	10¾	4½	2	2	⅜	⅝	24
XCE-080806	8 x 8 x 6	10¾	4½	2	2	⅜	⅝	28
XCE-080808	8 x 8 x 8	10¾	4½	2	2	⅜	⅝	35
XCE-081004	8 x 10 x 4	10¾	6½	3	3	⅜	⅝	30
XCE-081006	8 x 10 x 6	10¾	6½	3	3	⅜	⅝	34
XCE-081008	8 x 10 x 8	10¾	6½	3	3	⅜	⅝	39
XCE-081204	8 x 12 x 4	10¾	8½	2	4	⅜	⅝	34
XCE-081206	8 x 12 x 6	10¾	8½	3	4	⅜	⅝	42
XCE-081208	8 x 12 x 8	10¾	8½	3	4	⅜	⅝	48
XCE-101004	10 x 10 x 4	13	6½	3	3	⅜	⅝	34
XCE-101006	10 x 10 x 6	13	6½	3	3	⅜	⅝	44
XCE-101008	10 x 10 x 8	13	6½	3	3	⅜	⅝	50
XCE-101404	10 x 14 x 4	13	10⅝	3	5	⅜	⅝	42
XCE-101406	10 x 14 x 6	13	10⅝	3	5	⅜	⅝	49
XCE-101408	10 x 14 x 8	13	10⅝	3	5	½	⅝	57
XCE-121204	12 x 12 x 4	15¾	8⅝	4	4	½	13/16	60
XCE-121206	12 x 12 x 6	15¾	8⅝	4	4	½	13/16	68
XCE-121208	12 x 12 x 8	15¾	8⅝	4	4	½	13/16	80
XCE-121804	12 x 18 x 4	15¾	14⅛	4	6	½	13/16	85
XCE-121806	12 x 18 x 6	15¾	14⅛	4	6	½	13/16	93
XCE-121808	12 x 18 x 8	15¾	14⅛	4	6	½	13/16	101
XCE-122005	12 x 20 x 5	15¾	14⅜	4	7	½	13/16	104
XCE-122404	12 x 24 x 4	15¾	18⅜	4	9	½	13/16	116
XCE-122406	12 x 24 x 6	15¾	18⅜	4	9	½	13/16	127
XCE-122408	12 x 24 x 8	15¾	18⅜	4	9	½	13/16	140
XCE-122410	12 x 24 x 10	15¾	18⅜	4	9	½	13/16	154
XCE-123604	12 x 36 x 4	15¾	29	4	14	⅝	1	192
XCE-123606	12 x 36 x 6	15¾	29	4	14	⅝	1	212
XCE-123608	12 x 36 x 8	15¾	29	4	14	⅝	1	232
XCE-141404	14 x 14 x 4	17¾	9¾	4	4	½	13/16	91
XCE-141406	14 x 14 x 6	17¾	9¾	4	4	½	13/16	97
XCE-141408	14 x 14 x 8	17¾	9¾	4	4	½	13/16	103
XCE-142806	14 x 28 x 6	17¾	22½	4	10	½	13/16	120
XCE-161604	16 x 16 x 4	19¾	11	5	5	⅝	1	114
XCE-161606	16 x 16 x 6	19¾	11	5	5	⅝	1	135
XCE-161608	16 x 16 x 8	19¾	11	5	5	⅝	1	156
XCE-162406	16 x 24 x 6	19¾	18⅜	5	8	⅝	1	190
XCE-162408	16 x 24 x 8	19¾	18⅜	5	8	⅝	1	209
XCE-162410	16 x 24 x 10	19¾	18⅜	5	8	⅝	1	225
XCE-181804	18 x 18 x 4	21¾	13	6	6	⅝	1	154
XCE-181806	18 x 18 x 6	21¾	13	6	6	⅝	1	177
XCE-181808	18 x 18 x 8	21¾	13	6	6	⅝	1	200
XCE-182406	18 x 24 x 6	21¾	18⅜	6	8	⅝	1	226
XCE-182408	18 x 24 x 8	21¾	18⅜	6	8	⅝	1	239
XCE-182410	18 x 24 x 10	21¾	18⅜	6	8	⅝	1	260
XCE-183608	18 x 36 x 8	21¾	29	6	13	⅝	1	318
XCE-183610	18 x 36 x 10	21¾	29	6	13	⅝	1	340
XCE-242408	24 x 24 x 8	28	18⅜	8	8	⅝	1	302
XCE-242410	24 x 24 x 10	28	18⅜	8	8	⅝	1	330
XCE-243008	24 x 30 x 8	28	23	8	11	⅝	1	356
XCE-243608	24 x 36 x 8	28	29	8	13	⅝	1	408

Consult factory for UL/CSA certification availability.
Compliances: NEC Class I, Group C & D • Class II, Groups E, F, G • Class III
UL Standard 886 • CSA Standard C22.2 No. 30

OPERATORS

CLASS I, GROUPS C & D; CLASS II, GROUPS E, F, & G;

FOR XCE-XIF-XB SERIES EXPLOSION PROOF CONTROL ENCLOSURES

APPLICATIONS

Adalet operators are for use in control circuits functioning in environments containing hazardous gases, vapors or dusts. These heavy duty pilot lights, pushbuttons and selector switches are suitable for use in Class I, Groups C & D hazardous gas; Class II, Groups E, F & G dust atmospheres. Most are suitable for weather-tight (N4) applications.

FEATURES:

- Most operators are suitable for NEMA 3, 4, NEMA 7, 9, rain-tight, water-tight in hazardous environments.
- Two lengths available for either surface or panel mount.
- Knurled caps are standard with black anodized finish.
- Optional: specify color-coding of operator caps (no additional cost)
- Pilot light transformers available for 120, 240 and 480 volts.
- Special lengths pilot light wiring leads available.
- Alodine coated process, minimize corrosion and provides for ease of installation.
- All operators are ¾" NPSM standard.
- Stainless steel shafts, standard (except pilot light pushbutton operator).

Consult factory for UL/CSA certification availability.
Compliances: NEC Class I, Groups C & D • Class II, Groups E, F, G • Class III
UL Standard 886 • Standard C22.2 No. 30

NOTE: Where reference is made to Class I and Class II hazardous locations, the equipment is suitable for use in both Division 1 and Division 2 hazardous locations.

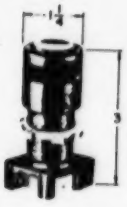
The Adalet engineering department is available to provide custom explosion-proof housings for your products.

EXPLOSION-PROOF AND DUST-TIGHT PUSH BUTTONS

CLASS I, GROUPS C & D; CLASS II, GROUPS E, F, & G; NEMA 3, 4, 7, 9

Push Button Operators for XCE, XIF and XB Enclosures

XHPB



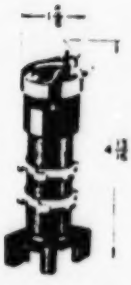
XHPBS

XHPBM

XHPBMS

XHPPM

XHPPMS



XHPBPL

XHPBSPL

All operators are die cast aluminum alloy. The barrels are all ¾" NPSM Thread. Operators can be spaced vertically on 2½" centers, horizontally on 2½" centers. Maximum wall thickness 1 15/16" panel mount, 13/16" surface mount.

All operators have black molded nylon buttons. The exposed metal parts are black anodized aluminum. For color coding we will furnish at no additional cost the following color combinations. Red buttons with red metal caps. Green buttons with green metal caps. Metal caps are also available in blue, gold or clear with black buttons. Specify colors required.

Red Mushroom head buttons are 1¾" diameter anodized aluminum. Also available in black or green.

XHPBPL has padlock attachment on top of cap allowing operator to be locked with the push button depressed.

For use with BT contact blocks. Contact blocks can be stacked for multiple circuits. Contact blocks are not included with the operators. Order from page XCE-34.

Catalog Number For use with series BT contact blocks	Description of Operators only	Weight Each Pounds
XHPB	Panel Mount	½
XHPBS	Surface Mount	½
XHPBM	Red Mushroom Head, Panel Mount	½
XHPBMS	Red Mushroom Head, Surface Mount	½
XHPBPL	W/Padlock devices, Panel Mount	¾
XHPBSPL	W/Padlock devices, Surface Mount	¾
XHPPM	Push/Pull switches Panel Mount	¾
XHPPMS	Push/Pull switches Surface Mount	¾

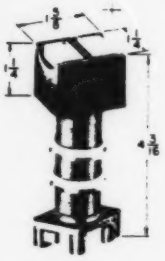
Legend nameplates, see page XCE-32.

For Wet-Dirty Location Applications Use Protective Boots Page XCE-33.

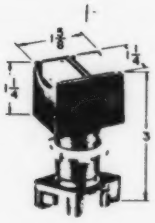
EXPLOSION-PROOF AND DUST-TIGHT PUSH BUTTONS

CLASS I, GROUPS C & D; CLASS II, GROUPS E, F, & G; NEMA 3, 4, 7, 9

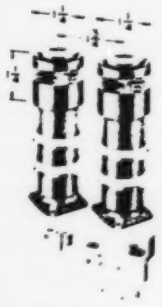
Dual Push Button Operator or Maintained Contact Unit For XCE, XIF and XB Enclosures



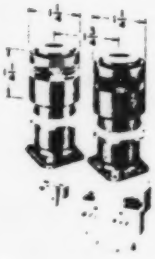
XHDPB
XHDMC



XHDPBS
XHDMCS



XHMCD



XHMCSD

All operators are die cast aluminum alloy. The barrels are all ¾" NPSM Thread. Operators can be spaced vertically on 2½" centers, horizontally on 2½"centers. Maximum wall thickness 1 15/16" panel mount, 13/16" surface mount.

For use with BT contact blocks. Contact blocks can be stacked for multiple circuits. Contact blocks are not included with the operators. Order from page XCE-34.

Catalog Number For use with series BT contact blocks	Description of Operators only	Weight Each Pounds
XHDPB	Panel Mount	½
XHDPBS	Surface Mount	½
XHDMC	Maintained Contact Panel Mount	½
XHDMCS	Maintained Contact Surface Mount	½

Furnished with one Contact Block	Description of Operators only	Weight Each Pounds
XHMCD	Maintained Contact Unit 2 Push Buttons, Panel Mount	1
XHMCSD	Maintained Contact Unit 2 Push Buttons, Surface Mount	1
XHMCMD	Maintained Contact Unit 2 Push Buttons, Panel Mount With one mushroom and one standard button	1
XHMCMSD	Maintained Contact Unit 2 Push Buttons, Surface Mount With one mushroom and one standard button	1

The XHMCD and XHMCSD Maintained contact units are complete with one contact block. These units consist of two operators and require (2) positions.

Legend nameplates, see page XCE-32.

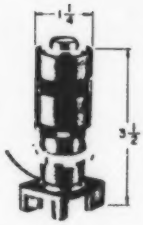
AVAILABLE: PROTECTIVE BOOTS
See page XCE-33.

EXPLOSION-PROOF AND DUST-TIGHT PILOT LIGHT PUSH BUTTONS

CLASS I, GROUPS C & D; CLASS II, GROUPS E, F, & G; NEMA 7, 9

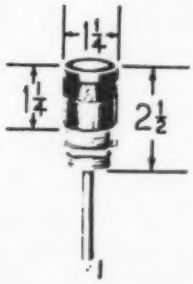
Indicator Light/Push Button Push-To-Test Operators For XCE, XIF and XB Enclosures

XLP Long Series
(Panel Mount)



XLPS Short Series
(Surface Mount)

PATENTED



XRB

XPP
BLACK ANODIZED

All operators are die cast aluminum alloy. The barrels are all ¾" NPSM Thread. Operators can be spaced vertically on 2½" centers, horizontally on 2½" centers. Maximum wall thickness 1 5/16" panel mount, 13/16" surface mount.

Furnished standard with 120 volt slide base lamp. Also available for 6, 12, 24, 28, 48 and 60 volts. Specify when ordering.

For use with BT contact blocks. Contact blocks can be stacked for multiple circuits. Contact blocks are not included with the operators. Order from page XCE-34. For NEMA 4 application add boot and special nameplate, see page XCE-33.

Catalog Number For use with series BT contact blocks	Description of Operators only	Weight Each Pounds
XLPA	Amber lens	¾
XLPB	Blue lens	¾
XLPC	Clear lens	¾
XLPG	Green lens — For Panel Mounting	¾
XLPR	Red lens	¾
XLPW	White lens	¾
XLPAS	Amber lens	½
XLPBS	Blue lens	½
XLPCS	Clear lens	½
XLPGS	Green lens — For Surface Mounting	½
XLPRS	Red lens	½
XLPWS	White lens	½

Legend nameplates, see page XCE-32.

Reset Button Operators

Catalog Number	Description of Operations only	Weight Each Pounds
XRB	Reset Button	½

Used for resetting contactors, relays, etc. in explosion-proof and weather-proof enclosures. Made with ¾" NPSM threaded stem. Standard operating shaft length 6" can be cut to length. Special lengths are available.

Close Up Plugs

For Unused Operator Openings

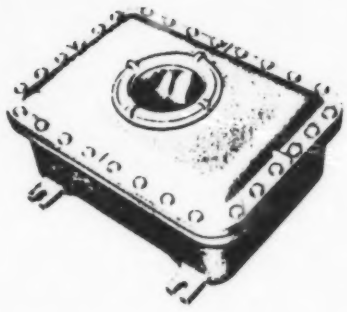
Catalog Number	Description	Net Weight
XPP	¾" NPSM	¾ oz.

GLASS WINDOWS

For XCEB Series Explosion-Proof Control Enclosures

CLASS I, GROUPS B, C & D; CLASS II, GROUPS E, F, & G
NEMA 3, 4* (OPTIONAL), NEMA 7, 9

(Glass window catalog number includes installation)



XCEB with window installed

Dimensional Data

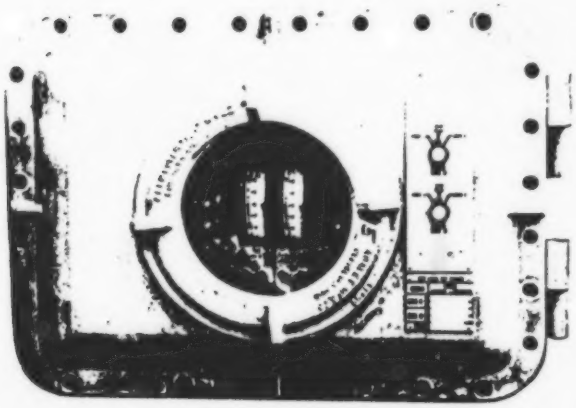
Catalog Number	Glass Window View Opening	Overall Window Cover Dia.	Min. Length and Width†	Cover Thread
XGC-40GB	2 1/16" diameter	6 3/8" diameter	10"	5 1/2"-12
XGC-52GB	4 1/8" diameter	7 7/8" diameter	10"	7 1/8"-12
XGC-66GB	6 1/8" diameter	10 3/8" diameter	14"	9 1/8"-12

†Reference to inside enclosure dimensions required to accommodate respective glass window installations.

*Rain-tight, water-tight NEMA 3, 4 optional feature. Add suffix N4 to glass window catalog number.

NOTE: Combination of glass windows, pushbuttons, pilot lights, selector switches and other accessory installations, please consult factory or submit sketch.

TYPICAL CUSTOM MODIFICATION

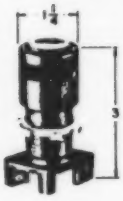


EXPLOSION-PROOF AND DUST-TIGHT PUSH BUTTONS

CLASS I, GROUPS B, C & D; CLASS II, GROUPS E, F, & G; NEMA 3, 4, 7, 9

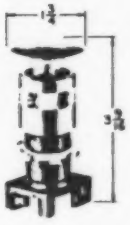
Push Button Operators for XCEB Enclosures

XHPBH



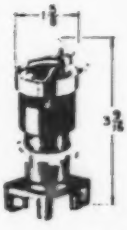
XHPBSH

XHPBMH



XHPBMSH

XHPBPLH



XHPBSPLH

All operators are die cast aluminum alloy. The barrels are all ¾" NPSM Thread. Operators can be spaced vertically on 2½" centers, horizontally on 2½"centers. Maximum wall thickness 1 15/16" panel mount, 13/16" surface mount.

All operators have black molded nylon buttons. The exposed metal parts are black anodized aluminum. For color coding we will furnish at no additional cost the following color combinations. Red buttons with red metal caps. Green buttons with green metal caps. Metal caps are also available in blue, gold or clear with black buttons. Specify colors required.

Red Mushroom head buttons are 1¾" diameter anodized aluminum. Also available in black or green.

XHPBPLH has padlock attachment on top cap allowing operator to be locked with the push button depressed.

For use with BT contact blocks. Contact blocks can be stacked for multiple circuits. Contact blocks are not included with the operators. Order from page XCE-34.

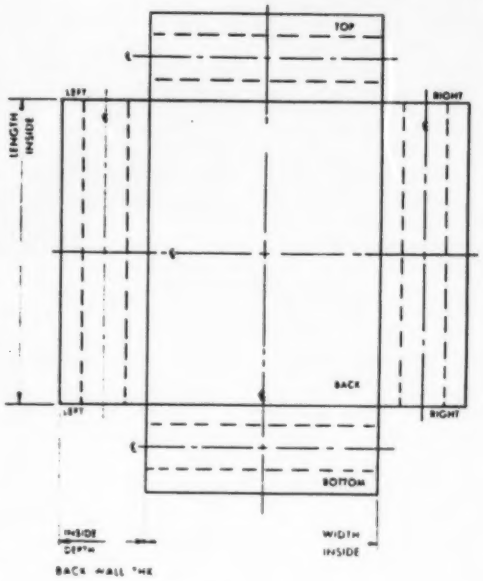
Catalog Number For use with series BT contact blocks	Description of Operators only	Weight Each Pounds
XHPBH	Panel Mount	½
XHPBSH	Surface Mount	½
XHPBMH	Red Mushroom Head, Panel Mount	½
XHPBMSH	Red Mushroom Head, Surface Mount	½
XHPBPLH	W/Padlock devices, Panel Mount	¾
XHPBSPLH	W/Padlock devices, Surface Mount	¾

Legend nameplates, see page XCE-32.

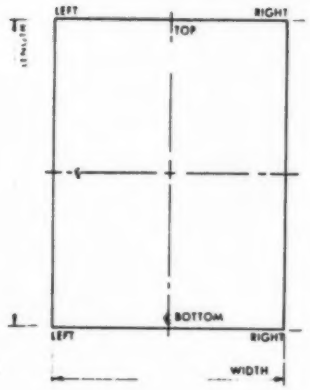
For Wet-Dirty Location Applications Use Protective Boots Page XCE-33.

EXPLOSION-PROOF AND DUST-TIGHT JUNCTION BOXES

DRILLING AND TAPPING LAYOUT INSTRUCTIONS



Box Layout



Cover Layout

The Adalet Engineering Department is available to provide custom explosion-proof housings for your products.

When ordering Adalet Junction Boxes or Housings, it is well to prepare a layout like the one shown. This is a developed view of a box with the sides laid outward. All dimensions are inside ones. On the layout locate the required conduit holes, pads and lugs. Show pipe size and exact location. To help you do this we have provided the two "Conduit Layout Tables" on this page. NOTE that the catalog numbers and prices cover the blank box. To this base price, add the price of the conduit holes, and any pads required.

STANDARD CONDUIT LAYOUT DIMENSIONS ARE FROM CENTER LINE OF BOX TO CENTER LINE OF CONDUIT.

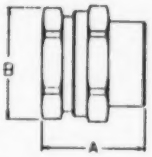
CONDUIT SIZE	½	¾	1	1¼	1½	2	2½	3	3½	4
Explosion proof										
Required Wall Thickness For 5 Full Threads	⅜	⅜	7/16	7/16	7/16	7/16	⅜	⅜	⅜	⅜
Dust Tight Weather Proof										
Required Wall Thickness For 3½ Full Threads	¼	¼	5/16	5/16	5/16	5/16	7/16	7/16	7/16	7/16

CONDUIT LAYOUT TABLES

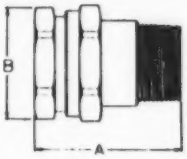
CONDUIT SIZE	Recommended Minimum Spacing - Conduit Centers										INSIDE EDGE OF BOX TO C OF UNION	APPROX DIA. OF UNION
	½	¾	1	1¼	1½	2	2½	3	3½	4		
½	2⅛	2⅛	2¼	2⅜	2 13/16	3⅛	3⅜	3 13/16	4 5/16	4 7/16	1 3/16	1⅞
¾	2⅛	2⅛	2¼	2⅜	2 13/16	3⅛	3⅜	3 13/16	4 5/16	4 7/16	1	1⅞
1	2¼	2¼	2⅜	2 13/16	2 13/16	3¼	3⅜	4 5/16	4 5/16	4½	1 5/16	2 5/16
1¼	2⅜	2⅜	2 13/16	3⅛	3 5/16	3⅜	4⅛	4 7/16	4 11/16	4 13/16	1 7/16	2⅜
1½	2 13/16	2 13/16	2 13/16	3 5/16	3½	3 13/16	4 5/16	4⅜	4⅞	5⅛	1¾	3¼
2	3⅛	3⅛	3¼	3⅜	3 13/16	4⅛	4⅜	4 13/16	5 5/16	5 7/16	2	3⅞
2½	3⅜	3⅜	3⅜	4⅛	4 5/16	4⅜	5⅛	5 7/16	5 11/16	5 13/16	2 5/16	4⅛
3	3 13/16	3 13/16	4 5/16	4 7/16	4⅜	4 13/16	5 7/16	5⅜	6	6¼	2⅜	5½
3½	4⅜	4⅜	4⅜	4 11/16	4⅞	5 3/16	5 11/16	6	6¼	6½	2⅞	6
4	4 7/16	4 7/16	4½	4 13/16	5⅛	5 7/16	5 13/16	6¼	6½	6¾	3¼	6½

EXPLOSION-PROOF AND DUST-TIGHT CONDUIT UNIONS
CLASS I, GROUPS A, B, C & D; CLASS II, GROUPS E, F & G; NEMA 7 & NEMA 9

XU



XUM



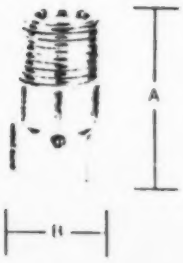
Explosion-proof unions for use in conduit piping systems for ease of installation and removal of fittings, boxes and equipment enclosures in hazardous atmosphere areas. Parts are steel, cadmium plated for corrosion protection. Style XU has two female NPT threads. Style XUM has two female NPT threads and one plated threaded nipple.

Catalog Number	Conduit Size (in.)	Description	Standard Package	
			Quantity	Weight, Pounds
XU2	½	Female-Female	50	19
XU3	¾	Female-Female	50	21
XU4	1	Female-Female	25	13½
XUM2	½	Female-Male	50	22
XUM3	¾	Female-Male	50	26
XUM4	1	Female-Male	25	16½

Nominal Dimensions (inches)			
Catalog Number	Conduit Size	A	B
Series XU	½	1¾	1½
	¾	1¾	1¾
	1	1 11/16	2
Series XUM	½	2½	1½
	¾	2¾	1¾
	1	3	2

Compliances: NEC Class I, Groups A, B, C, D
Class II, Groups E, F, G • Class III
UL Standard 866 • CSA Standard C22.2 No. 30

EXPLOSION-PROOF AND DUST-TIGHT COMBINATION BREATHER DRAIN
CLASS I, GROUPS C & D; CLASS II, GROUPS F & G; NEMA 7 & NEMA 9



Stainless steel combination breather drain. Install in top of enclosures as breather. Install in bottom of enclosure as drain.

Nominal Dimensions (inches)			
Catalog Number	Thread	A	B
XDB2	½ NPT	1⅛	⅞ hex

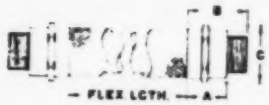
Compliances: NEC Class I, Group C and D
Class II, Groups F, G • Class III
UL Standard 886 • CSA Standard C22.2 No. 30

EXPLOSION-PROOF AND DUST-TIGHT FLEXIBLE COUPLINGS
CLASS I, GROUPS A, B, C, D*; CLASS II, GROUPS E, F & G; NEMA 7 & NEMA 9

Application: XFC couplings are for use in Hazardous Atmospheres where a flexible connection is required for motor and equipment installation where movement and vibration are present. Also for difficult bends and connections.

Material: Brass and Bronze end fittings, Bronze wire flexible braid covering over flexible Bronze core with insulating liner. INCLUDES TWO REMOVABLE CADMIUM PLATED STEEL NIPPLES.

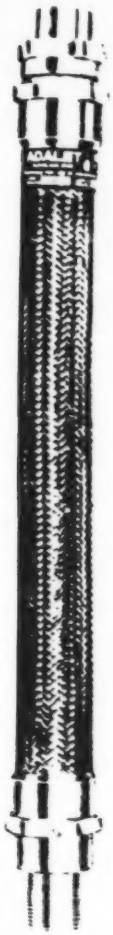
Nominal Dimensions (inches)							
Catalog Number	Conduit Size	Flex Length	Weight Pounds	Catalog Number	Conduit Size	Flex Length	Weight Pounds
XFC-24	½	4	1¼	XFC-410	1	10	2¾
XFC-26	½	6	2	XFC-412	1	12	2¾
XFC-28	½	8	2½	XFC-415	1	15	3
XFC-210	½	10	2¾	XFC-418	1	18	3¼
XFC-212	½	12	2½	XFC-421	1	21	3½
XFC-215	½	15	2⅞	XFC-424	1	24	3¾
XFC-218	½	18	3	XFC-427	1	27	4¼
XFC-221	½	21	3¼	XFC-430	1	30	4½
XFC-224	½	24	3¼	XFC-433	1	33	4¾
XFC-227	½	27	3⅜	XFC-436	1	36	5¼
XFC-230	½	30	3½	XFC-512	1¼	12	6½
XFC-233	½	33	3¾	XFC-515	1¼	15	7
XFC-236	½	36	4	XFC-518	1¼	18	7½
XFC-34	¾	4	2	XFC-521	1¼	21	8¼
XFC-36	¾	6	2¼	XFC-524	1¼	24	8¼
XFC-38	¾	8	2⅜	XFC-527	1¼	27	9½
XFC-310	¾	10	2½	XFC-530	1¼	30	10¼
XFC-312	¾	12	2¾	XFC-533	1¼	33	10¾
XFC-315	¾	15	3	XFC-536	1¼	36	11¼
XFC-318	¾	18	3¼	XFC-612	1½	12	8¼
XFC-321	¾	21	3¼	XFC-615	1½	15	9
XFC-324	¾	24	3¼	XFC-618	1½	18	10
XFC-327	¾	27	3½	XFC-621	1½	21	11
XFC-330	¾	30	3¾	XFC-624	1½	24	12
XFC-333	¾	33	4	XFC-627	1½	27	13
XFC-336	¾	36	4½	XFC-630	1½	30	14
XFC-46	1	6	2¼	XFC-633	1½	33	15
XFC-48	1	8	2½	XFC-636	1½	36	16



Nominal Dimensions (inches)						
Catalog Number	Conduit Size	Classification*	A	B	C	Max. Radius Bend
Series XFC	½	Class I & II	1 1⁵⁄₁₆	2⁹⁄₁₆	1⁷⁄₁₆	10
	¾	Group A,B,C,D,E,F & G	1¼	2 1⁵⁄₁₆	2	12
	1	Class I & II, Group C,D,E,F & G	2	3⅛	2⁷⁄₁₆	14
	1¼	Class I & II	2	3¼	2 ³³⁄₃₂	14
	1½	Group D,E,F & G	2½	3¼	3⅛	16

Compliances: NEC Class I, Groups A, B, C, D • Class II, Groups E, F, G • Class III UL Standard 886 • CSA Standard C22.2 No. 30

EXPLOSION-PROOF AND DUST-TIGHT FLEXIBLE COUPLINGS
CLASS I, GROUPS A, B, C, D*; CLASS II GROUPS E, F & G; NEMA 7 & NEMA 9



Application: XFC couplings are for use in Hazardous Atmospheres where a flexible connection is required for motor and equipment installation where movement and vibration are present. Also for difficult bends and connections.

Material: Brass and Bronze end fittings, Bronze wire flexible braid covering over flexible Bronze core with insulating liner. INCLUDES ONE FEMALE UNION AND ONE REMOVABLE CADMIUM PLATED STEEL NIPPLE.

Nominal Dimensions (inches)							
Catalog Number	Conduit Size	Flex Length	Weight Pounds	Catalog Number	Conduit Size	Flex Length	Weight Pounds
XFCU-24	½	4	2	XFCU-410	1	10	3
XFCU-26	½	6	2¼	XFCU-412	1	12	3¼
XFCU-28	½	8	2½	XFCU-415	1	15	3¾
XFCU-210	½	10	2¾	XFCU-418	1	18	3¾
XFCU-212	½	12	2¾	XFCU-421	1	21	3¾
XFCU-215	½	15	3⅛	XFCU-424	1	24	4⅛
XFCU-218	½	18	3¼	XFCU-427	1	27	4½
XFCU-221	½	21	3¾	XFCU-430	1	30	4¾
XFCU-224	½	24	3½	XFCU-433	1	33	5⅛
XFCU-227	½	27	3⅝	XFCU-436	1	36	5½
XFCU-230	½	30	3¾				
XFCU-233	½	33	4				
XFCU-236	½	36	4¼				
XFCU-34	¾	4	2¼				
XFCU-36	¾	6	2½				
XFCU-38	¾	8	2⅝				
XFCU-310	¾	10	2¾				
XFCU-312	¾	12	3⅛				
XFCU-315	¾	15	3¼				
XFCU-318	¾	18	3⅜				
XFCU-321	¾	21	3½				
XFCU-324	¾	24	3⅝				
XFCU-327	¾	27	3¾				
XFCU-330	¾	30	4				
XFCU-333	¾	33	4¼				
XFCU-336	¾	36	4¼				
XFCU-46	1	6	2¾				
XFCU-48	1	8	2¾				

Nominal Dimensions (inches)								
Catalog Number	Conduit Size	Classification*	A	B	C	D	E	Max. Radius Bend
Series XFCU	½	Class I & II Group A,B,C,D,E,F & G	1 1/16	2 7/16	1 7/16	2 7/16	1½	10
	¾		1¼	2 11/16	2	2½	1¼	12
	1	Class I & II, Group C,D,E,F & G	2	3 1/16	2 7/16	2 11/16	2	14

Compliances: NEC Class I, Groups A, B, C, D • Class II, Groups E, F, G • Class III UL Standard 886 • CSA Standard C22.2 No. 30